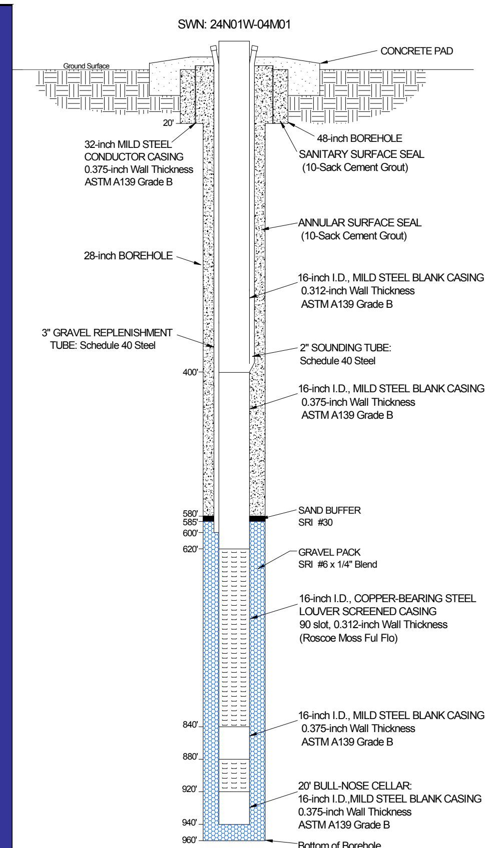
DEER CREEK WATER EXCHANGE 2003 PILOT PROGRAM

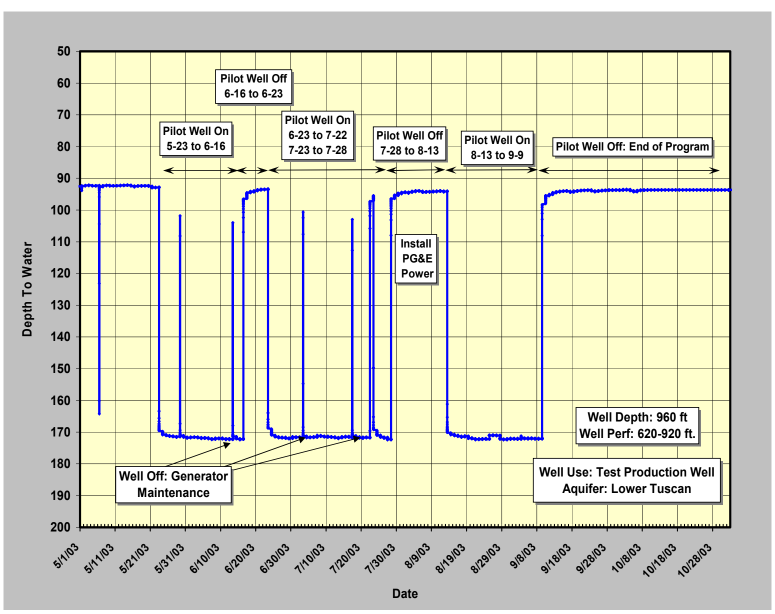
SUMMARY REPORT

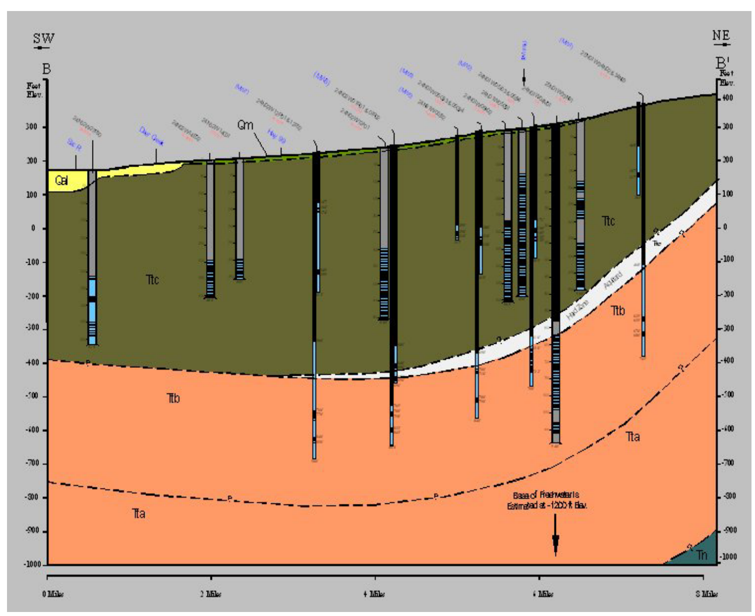
December 2003

Prepared By:
Deer Creek Irrigation District

In Cooperation with
Department of Water Resources
Northern District







STATE OF CALIFORNIA
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning and Local Assistance
Northern District, Groundwater Section

DEER CREEK WATER EXCHANGE PILOT PROGRAM SUMMARY REPORT

This summary report was prepared by the Department of Water Resource, Northern District, Groundwater Section, on behalf of the Deer Creek Water District. It was prepared under the direct supervision of Toccoy Dudley, Chief of the Northern District Groundwater Section, Registered Geologist No. 3732, and was written by Dan McManus, Registered Geologist No. 6261, in accordance with the provisions of the Geologist and Geophysicists Act of the State of California.

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INTRODUCTION

As part of the Deer Creek Water Exchange Pilot Program the Northern District Department of Water Resources and the Deer Creek Irrigation District (DCID) entered into an agreement to test the effectiveness of increasing the fish transportation flows in Deer Creek by utilizing groundwater in substitution of bypassed surface water. The primary focus of the pilot program was to ascertain groundwater level and water quality related impacts associated with pumping from the lower Tuscan aquifer with the recently completed test production pilot well. A secondary element of the pilot program was to evaluate newly developed guidelines for program operations and management. The guidelines, or Groundwater Management Objectives, are designed to prevent third party impacts by combining a rigorous program of groundwater monitoring with a clear set of groundwater level and groundwater quality criteria to guide groundwater pumping operations. Funding for the Deer Creek Water Exchange Pilot Program is through the Delta Pumping Plant (Four Pumps) Fish Protection Agreement.

Because the Pilot Program sought to pump groundwater into the DCID distribution system for off-parcel use, in accordance with Title 9, Chapter 9.40 of the Tehama County Code, a Groundwater Extraction and Exportation Permit was required. Deer Creek Irrigation District applied for, and was granted, Groundwater Extraction and Exportation permit WE-03/01 by Tehama County on April 22, 2003. Conditions governing the permit included:

1. Overdraft of the water table shall not occur.
2. Monitoring of the surface and groundwater systems shall comply with Appendix A, Attachment 1, Groundwater Management Objectives of the permit application and report.
3. Field measurement of conductivity shall be conducted and evaluated on a weekly basis.
4. Report project status and monitoring results on a monthly basis to the Tehama County Flood Control & Water Conservation AB3030 Technical Advisory Committee.
5. Report project status and monitoring results of the 30-day and 60-day summer pump testing to the Tehama County Board of Supervisors at a regularly scheduled meeting following pump testing.
6. Report all surface and groundwater levels and quality testing results to the Tehama County Flood Control & Water Conservation AB3030 Technical Advisory Committee.
7. During the 30-day and 60-day pumping times. All data collection shall occur weekly for the first three weeks, followed by semi-weekly monitoring.
8. Deer Creek Water Advisory Committee membership shall include a representative of the Tehama County Flood Control & Water Conservation District staff.
9. The total volume of extracted groundwater shall be limited to a maximum of 550 acre-feet for a maximum of 90 days between April and October.

This report provides pilot well data that was not fully available at the time of the Tehama County permit application, and summarizes the Pilot Program operations, management, monitoring and costs, and presents findings and recommendations for future work. A copy of the Tehama County Groundwater Extraction Permit and the Groundwater Management Objectives for the Pilot Program are presented in Appendix A. Geologic maps, key well hydrographs, deep aquifer hydrographs, water quality data and surface water flow data are presented in Appendix B, C, D, E and F, respectively. Project location map is shown in Figure 1.

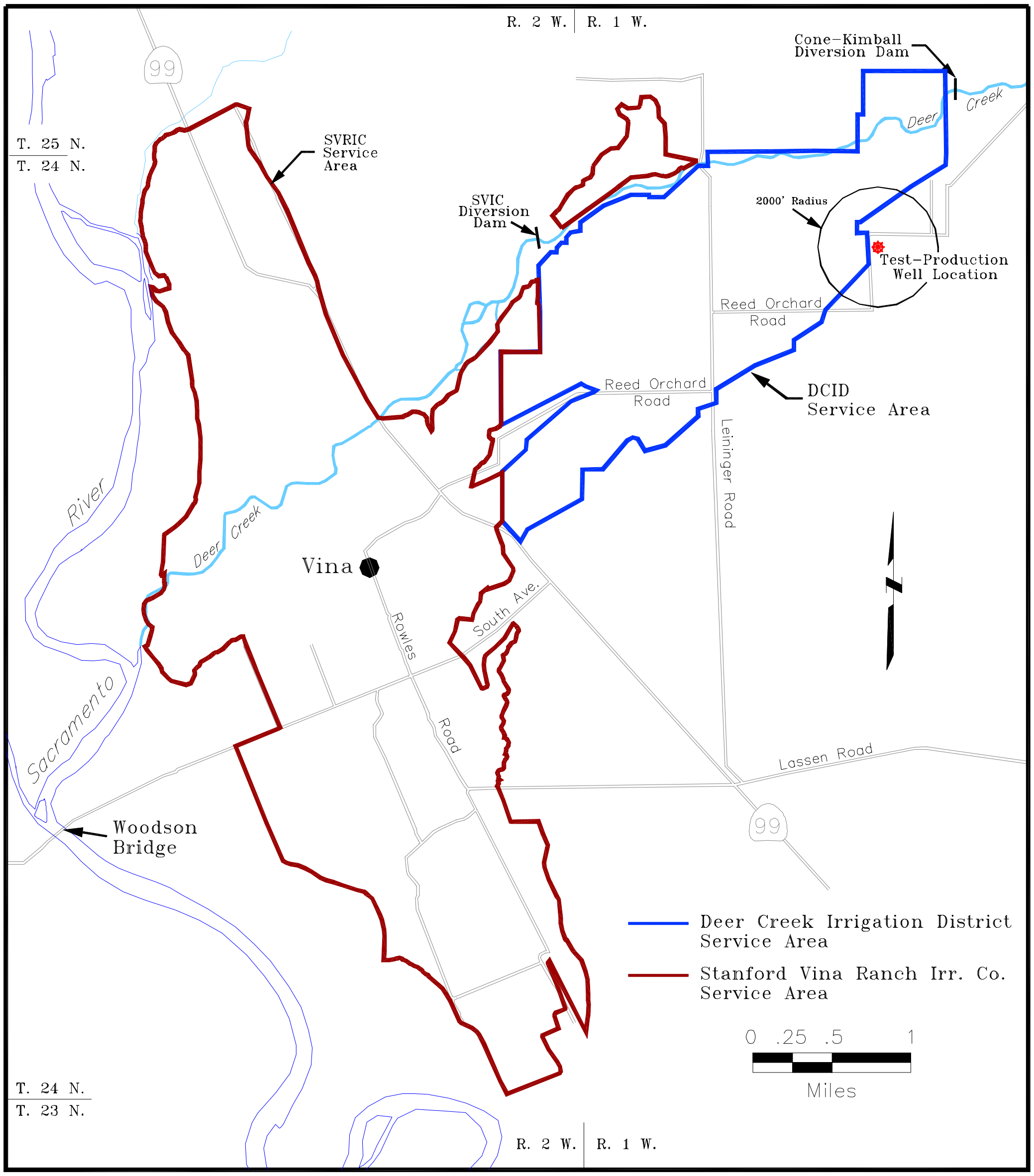


Figure 1. Project Location Map

PILOT WELL TESTING DATA

In February, 2003 step-drawdown and constant-discharge tests were conducted to determine the optimum discharge rate that could be maintained by the pilot well, the efficiency of the pilot well over a range of capacities and performance of the lower Tuscan aquifer. Much of these data were not available at the time the Tehama County Groundwater Extraction Permit, but were provided in part, at a later date as an addendum to the groundwater extraction permit. The following section provides a more inclusive presentation of the test data.

The step-drawdown test consisted of pumping the pilot well over four steps of incrementally increasing discharge, while measuring drawdown in the pilot well and the nearby monitoring wells. Groundwater discharge at each step was: 500 gpm, 1,000 gpm, 1,500 gpm and 2,000 gpm.

Each step ran for approximately 90-minutes, or until groundwater levels in the pilot well became stable, i.e., reached equilibrium with the aquifer. Groundwater discharge from the pilot well was measured using a McCrometer in-line flow meter and periodically checked using a Panametric's ultrasonic flow meter. Based on the step-drawdown data, the specific capacity and percent well efficiency were calculated for each step interval.

The specific capacity of a well is the pumping rate divided by the total drawdown. Similar to well yield, specific capacity is a method of measuring well productivity. Specific capacity is usually reported in gallons per minute per foot of drawdown (gpm/ft). Figure 2 illustrates groundwater level drawdown versus time for the step-drawdown pumping and recovery periods. Step-drawdown test data indicates steady decline in specific capacity from 18.5 to 16.1 gpm/ft over the four pumping steps. The number of production wells that extract groundwater exclusively from the lower Tuscan aquifer are limited, thus a statistically meaningful comparison of specific capacity between the pilot well and similarly constructed wells is not possible. However, a test-production well of similar construction as the pilot well was drilled just west of Chico. Specific capacity for the Chico test-well ranged from 20 to 23 gpm/ft. Agricultural production wells in the nearby project area that produce from the middle to upper Tuscan aquifer have a specific capacity values ranging from 70 to 100 gpm/ft.

Step-drawdown data in Figure 2 also shows that the aquifer takes longer to reach equilibrium at the 1,500 gpm step and, at the 2,000 gpm step, groundwater levels continue to decline slightly through the end of the test.

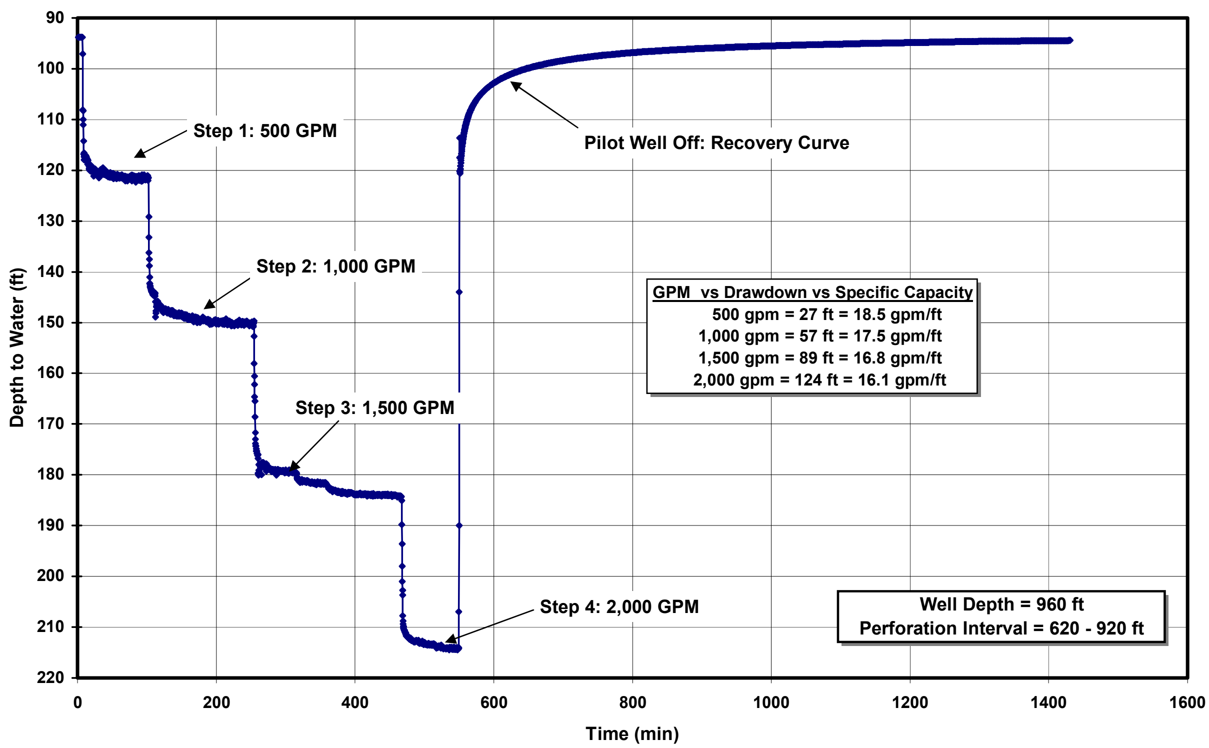


Figure 2. Step-Drawdown Test Results using the Pilot Well

The efficiency of the pilot well was determined by comparing actual drawdown versus theoretical groundwater level drawdown (aquifer loss) for each test step. Figure 3 illustrates the groundwater level drawdown, the estimated aquifer loss and calculated well efficiency over a range of discharge rates. Figures 2 and 3 indicate that although the pilot well appears to operate at a high efficiency throughout all of the production steps, the specific capacity and efficiency of the pilot well steadily declines as pumping capacities increase from 500 to 2,000 gpm. Preliminary results from the step-drawdown testing indicated that a production design capacity of 1,500 gallons per minute would be a reasonable compromise between maximizing pilot well capacity and minimizing operating cost.

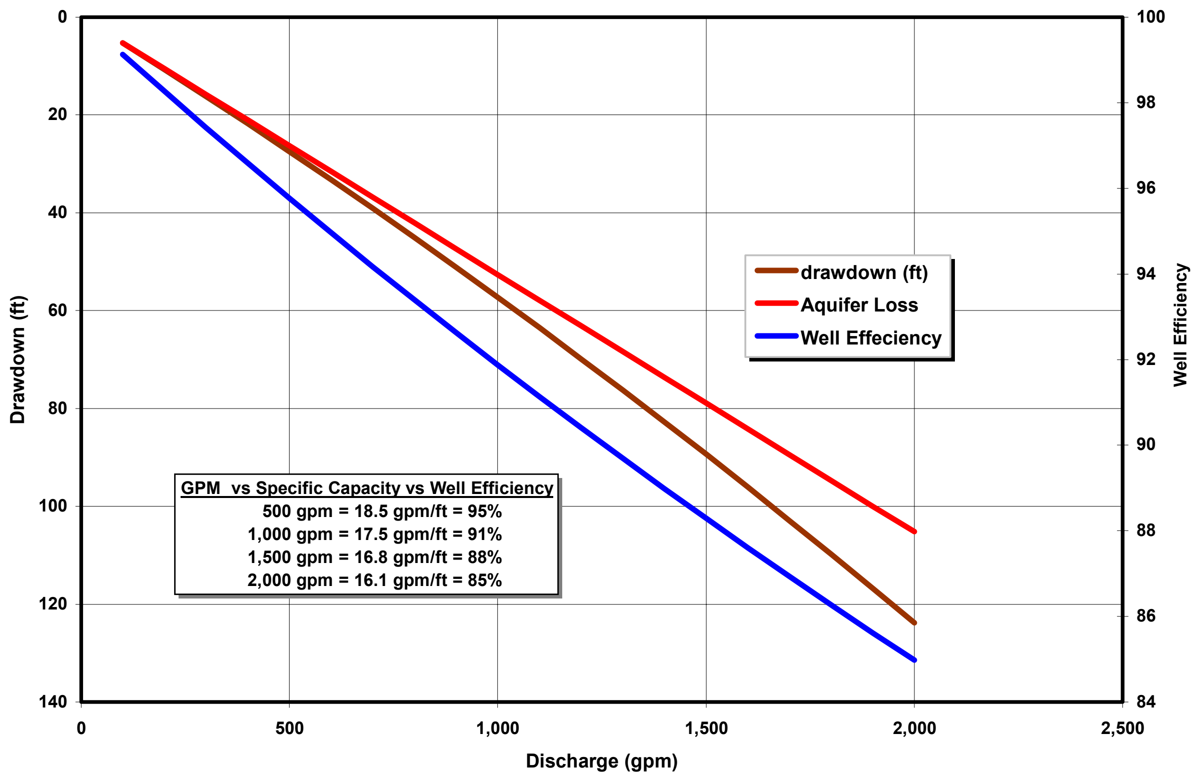


Figure 3. Pilot Well Efficiency Estimates.

A 48-hour aquifer performance test was conducted in late February 2003 to define the properties of the lower Tuscan aquifer and to verify the long-term ability to operate the pilot well at 1,500 gallons per minute without groundwater level impacts to the upper aquifer and significant further groundwater level declines in the lower Tuscan aquifer. Figure 4 shows the groundwater level data from the pilot well during the pumping and recovery periods.

The results in Figure 4 show that, at a capacity of 1,500 gallons per minute, groundwater levels in the pilot well continued to decline by about 15-20 feet throughout the 48-hour period. Recovery data indicates that groundwater levels recovered about 75 percent within 8 hours and 100 percent within 24-hours.

Transmissivity is a measure of the rate at which an aquifer can transmit water per unit decline in groundwater level. Estimates of transmissivity from the lower Tuscan aquifer during the 48-hour test ranged between 38,000 and 45,000 gallons per day, per foot of drawdown (gpd/ft). In comparison, transmissivity of the west Chico test-well, referred to earlier, is estimated to range between 50,000 and 75,000 gpd/ft. Agricultural production wells in the nearby project area that produce from the middle to upper Tuscan aquifer have transmissivity values ranging from

100,000 to 200,000 gpd/ft. Storativity values for the lower Tuscan were calculated at 4x10-6, which is characteristic of a highly confined aquifer.

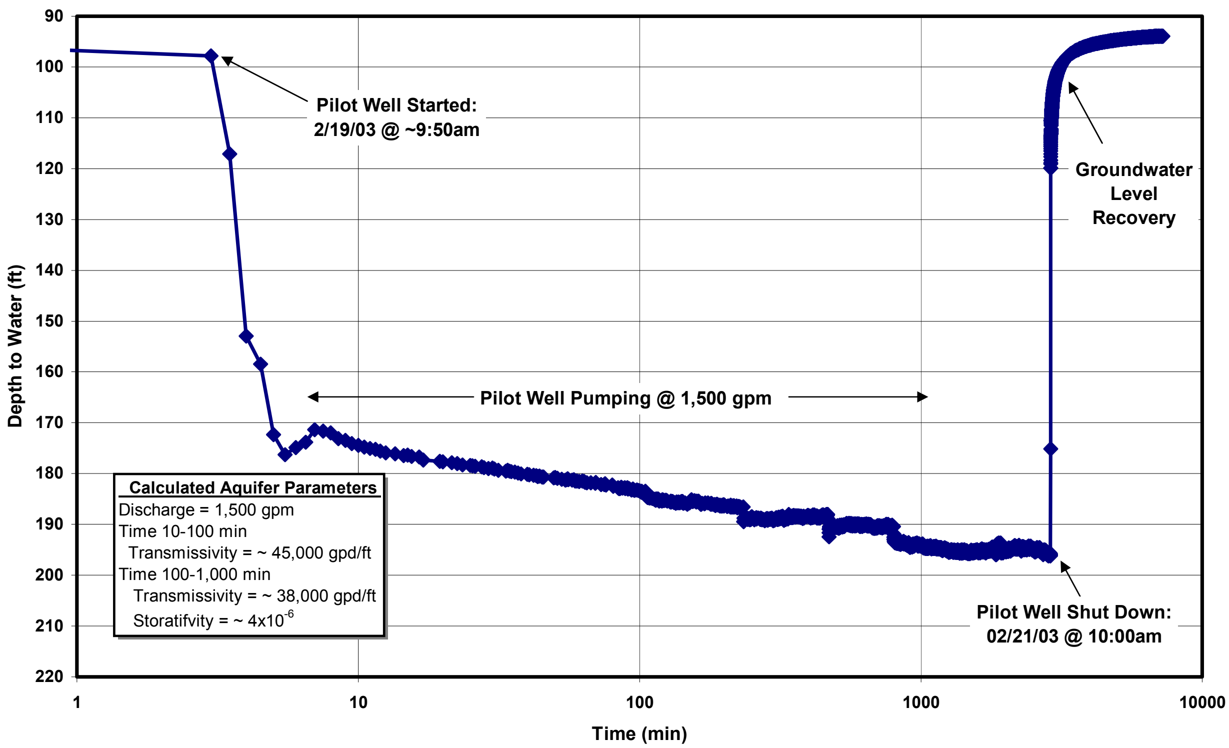


Figure 4. Pilot Well 48-Hour Constant-Discharge Aquifer Performance Test

Groundwater level monitoring in nearby wells during the 48-hour aquifer performance test showed no impacts in the upper to middle aquifer, while dedicated nearby monitoring wells completed into the lower Tuscan exhibited a groundwater level drawdown of up to 16 feet.

PILOT WELL DESIGN

The pilot well was designed and constructed to produce from the lower portion of the Tuscan aquifer, and to eliminate any pumping related impacts to nearby wells constructed in the upper to middle portions of the Tuscan aquifer. The pilot well is 940-feet deep with perforations between 620 and 920 feet, and a cement-bentonite seal down to a depth of 580 feet. As-built design of the pilot-well is shown in Figure 5.

Based on the results of the step-drawdown and 48-hour constant-discharge test, a final design capacity of 1,350 gpm was selected. The final design capacity was reduced from earlier estimates of 1,500 gpm in order to reduce groundwater level declines in the lower Tuscan during the anticipated 30 to 60-day operation periods.

The pilot well pump consists of a Goulds water lubricated lineshaft turbine pump with 12.38-inch, three stage bowls set at a depth of 260 feet. Power to the pump was provided by a 75 hp electric motor connected to a 200-amp soft-start electrical panel. Discharge line consists of an above-ground 10-inch steel casing connecting underground to 12-inch low-head PVC pipe running beneath Reed Orchard Road, and terminating into a 42-inch square outflow box adjacent to the DCID canal. An encroachment permit was obtained to run the discharge line beneath Reed Orchard Road. Where the discharge line travels beneath Reed Orchard Road, the 12-inch PVC pipe is placed inside a 15-inch class 125 PVC sleeve, for further protection and ease of removal. A 10-inch McCrometer flow meter was placed in the above-ground portion of the steel discharge line, approximately 7-feet from the well discharge head. Figure 6 shows the configuration of the well head and discharge box. Figure 7 shows the efficiency-curve for the selected Goulds pump bowls G13CMC-18-3. Total pumping plant efficiency calculated from summer energy use was determined to be 72 percent.

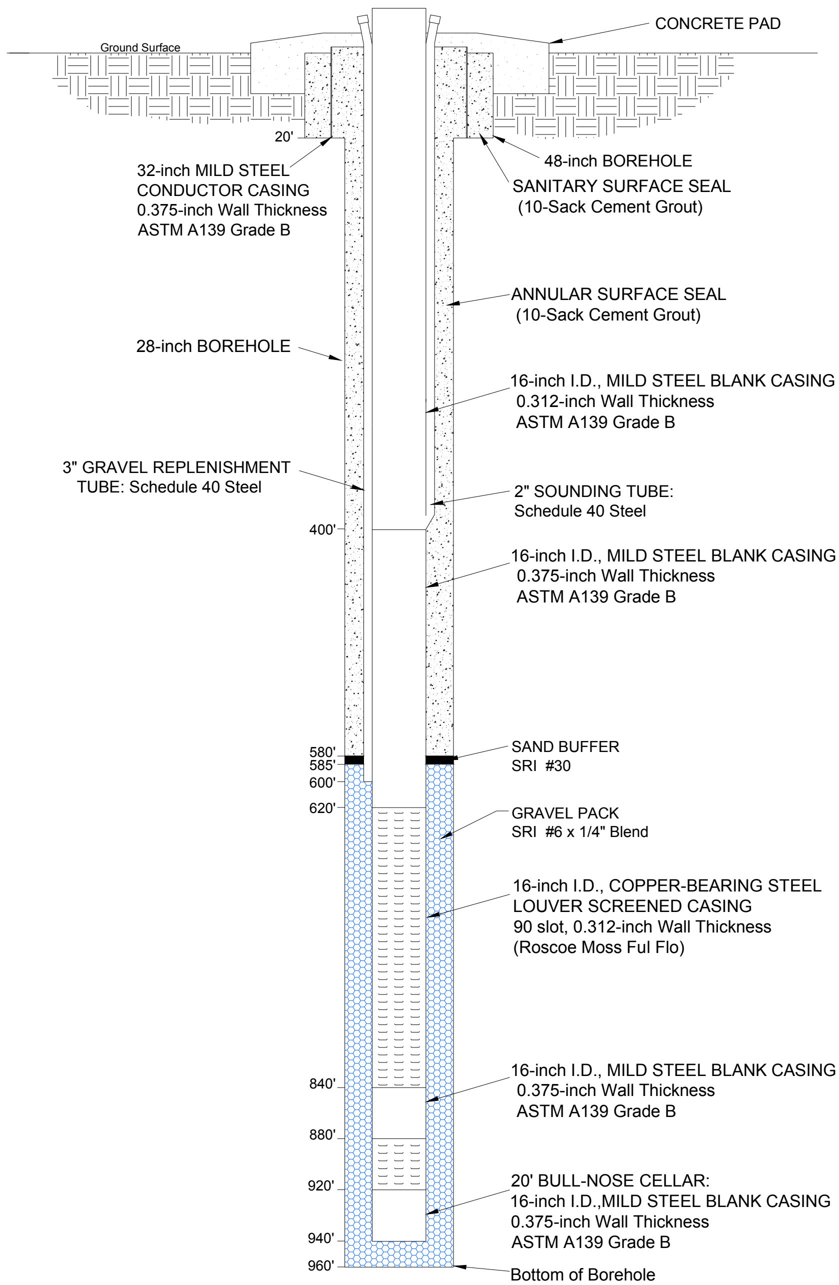
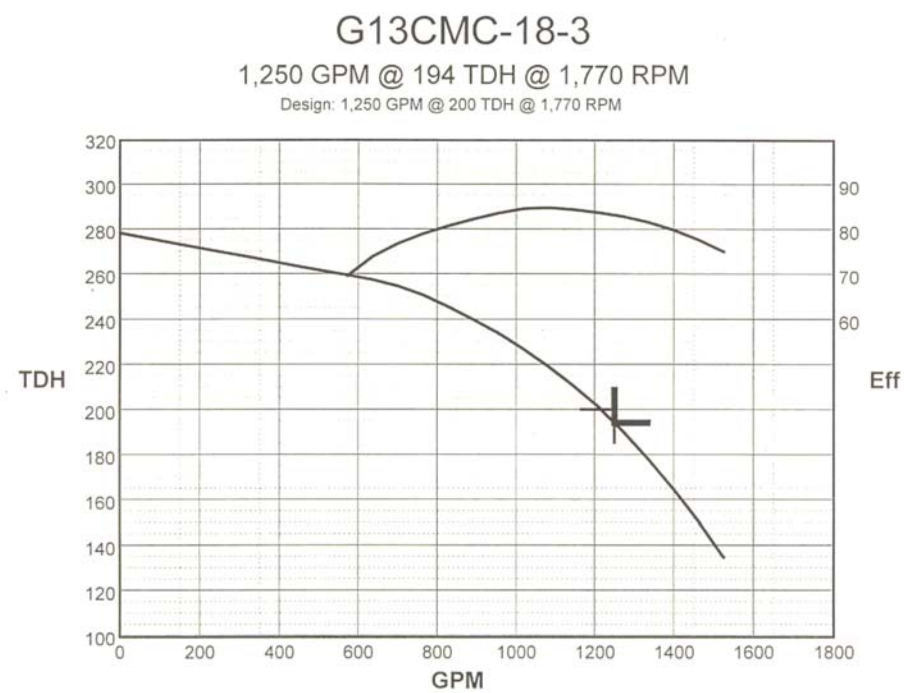


Figure 5. As-Built Design of the Pilot Well (SWN: 24N01W-04M01).

Figure 6. Pilot Well Head Configuration and Discharge Structure.



Impellers: Trim 3 - 8.60"

Bowl Diameter: 12.38

GPM	0	200	400	600	800	1,000	1,200	1,250	1,400	1,526
TDH	278	272	265	258	248	229	203	194	164	135
Eff				71.4	79.9	84.2	83.7	83.1	79.8	75.0
Hp				54.9	62.7	68.7	73.4	73.8	72.9	69.2
NPSHr				10.0	10.9	12.4	15.6	16.9	21.5	26.8

K Factor: 9.5000 Available Lateral: 0.88

Thrust @ Curve: 1,844.08 Max Curve Hp: 73.9

Figure 7. Efficiency-Discharge Curve for Pilot Well Pump Bowls.

PILOT WELL OPERATIONS

Operation of the pilot began on May 21, 2003 at approximately 12:00 noon. Unusually wet conditions through the late spring limited the need for additional agricultural water or fish transportation flows earlier in the season, and contributed to the decision as to when to start the well. Electricity to the well was temporarily supplied by a diesel generator until PG&E could provide a permanent source of electrical power.

One of the goals of the pilot program was to test the response of the lower and upper aquifer to extended periods of pumping during times of peak groundwater demand. Peak groundwater extraction in the project area typically occurs from late July to early August when agricultural demand is highest. Initially, the proposed schedule for operating the pilot well consisted of 30-days on, 7 to 15-days off, followed by 60-days on. In practice, the periods of continuous pumping were limited due to several instances of high temperatures causing overload and shutdown of the generator, and a two week pumping hiatus required for installation of PG&E electricity. Tables 1 and 2 provide a detailed list of the pilot well operating schedule, pumping rates and volumes.

Date & Time	Meter Reading Ave.Rate (gal/min)	Meter Reading Total Vol. (gallons)	Meter Reading Total Vol. (acre-feet)	Total Days Pumping	Remarks
5/21/03 12:08	0	8,699,000	0.00	0	Meter reading prior to start of well
5/23/03 11:00	~1300	8,699,000	0.00	2	Pilot well turned on at ~11:00.
5/28/03 9:27	1,200	17,273,000	26.31	7	Pump Running
6/3/03 10:53	1,200	27,704,000	58.32	11	Pump Running
6/5/03 9:50	1,200	31,112,000	68.77	13	Pump Running
6/12/03 9:10	1,200	43,236,000	105.97	20	Pump Running
6/23/03 14:30	N/A	50,289,000	127.62	24	Pump Off 6-16-03 @ 11:30
6/24/03 13:30	1,200	51,771,000	132.16	25	Pump On 6-23-03 @ 11:30
7/2/03 6:25	1,200	65,442,000	174.11	33	Pump Running
7/7/03 16:30	1,200	74,334,000	201.40	38	Pump Running
7/11/03 13:30	1,200	81,074,000	222.08	42	Pump Running
7/18/03 9:10	1,200	92,821,000	258.12	49	Pump Running
7/23/03 6:20	N/A	100,135,000	280.56	52	Pump Off_7/22 to 7/23pm
7/27/03 7:55	1,150	106,396,000	299.78	56	Pump On
7/30/03 10:30	N/A	108,105,000	305.02	57	Pump Off_7/28 to 8/13pm
8/13/03 8:00	1,250	108,107,000	305.03	58	Pump on 8/13 @ ~8:00am
8/19/03 13:15	1,200	118,880,000	338.08	64	Pump Running
8/25/03 6:30	1,150	128,785,000	368.47	70	Pump Running
8/28/03 10:45	1,150	134,266,000	385.29	73	Pump Running
9/9/03 16:47	1,150	155,459,000	450.32	85	Shut Pump Off at 16:47
	Totals:	**155,459,000**	**450**	**85**	**End of Program Pumping**

Table 1. Pilot Well Operating Schedule, Pumping Rates and Volume Totals.

Pumping Schedule	Days ON	Days OFF	Remarks
Pump On: 5/23 to 6/16	24		Pump On
Pump Off: 6/16 to 6/23		6	Pump Off Due to Generator Problems
Pump On: 6/23 to 7/22	29		Pump On
Pump Off: 7/22 to 7/23		1	Pump Off Due to Generator Problems
Pump On: 7/23 to 7/28	5		Pump On
Pump Off: 7/28 to 8/13		15	Pump Off: Installing PG&E Power
Pump On: 8/13 to 9/09	27		Pump On
Pump Off: 9/09			Pump Off: End of Pilot Program
Total:	**85**	**22**	**End of Program Pumping**

Table 2. Breakdown of Pilot Well Operating and Non-operating Periods

Operation of the pilot well terminated on September 9, 2003. Overall, the pilot well operated for a total of 85-days, with three continuous pumping periods of 24, 29 and 27-days. The total volume of groundwater extracted during the program was approximately 450 acre-feet.

The Tehama County Groundwater Extraction Permit allowed for a maximum of volume of 550 acre-feet over 90-days between April and October. Because orchard harvest activities limited the immediate need for additional water towards the end of the pilot program, DCID requested the pilot well be turned off several days prior to the 90-day pumping limit to reserve a portion of the permitted groundwater extraction for possible post-harvest irrigation demand. It was later determined that the existing surface water supplies were adequate for post-harvest demand so the full 90-day pumping allowance was not utilized.

PILOT PROGRAM MONITORING AND MANAGEMENT

Management of the pilot program followed the conditions set forth in the Tehama County Groundwater Extraction and Exportation permit and the guidelines outlined in the Deer Creek Water Exchange Program Groundwater Management Objectives. The goal of the groundwater management objectives was to operate the program so as to maintain a sustainable supply of high quality and affordable groundwater for irrigation and domestic use. Management of the pilot program was designed to prevent third party impacts by linking a rigorous schedule of monitoring to a clear set of groundwater level and water quality objectives, and corresponding guidelines for operations management. Monitoring results were reviewed on a monthly basis by the local Water Advisory Committee, the DCID board and the Tehama County Flood Control Water Conservation Board. A detailed explanation of the pilot program monitoring and management plan is provided in Appendix A. A summary of the management methods and the results from the groundwater level, water quality and surface water monitoring are provided below.

Groundwater Level Monitoring and Program Management

One of the key criteria for program operations was maintaining a predetermined range of acceptable groundwater levels in seven "key wells" surrounding the pilot well. The key wells were selected based on their depth and construction, their proximity to the pilot well, and their ability to represent groundwater levels in surrounding agricultural and domestic wells that extract groundwater from the upper to middle portions of the Tuscan aquifer. Groundwater levels in the key monitoring wells were monitored to determine compliance with the predetermined range of acceptable groundwater level fluctuations.

The acceptable range of groundwater level fluctuation during program operations was established based on professional judgment and the evaluation of:

- Historic seasonal fluctuation of groundwater levels in domestic and agricultural wells surrounding the pilot well,
- The estimated decline in groundwater levels associated with pumping of the pilot well, and
- Assurances that nearby third-party groundwater users will be able to maintain an adequate and affordable supply of good quality groundwater for agricultural and domestic use.

In order to have adequate time to respond and make appropriate adjustments to program operations, the groundwater level criteria were divided into three stages, or levels, which served as trigger points for reevaluating, altering, or shutting-down program operations and alleviating any additional groundwater level decline. Management guidelines allowed for the pilot program to proceed as long as groundwater level monitoring indicated compliance with the predetermined range of acceptable groundwater level decline. At the onset of the program it was understood that adjustments to the warning stage criteria may be needed as additional data was collected and experience was gained during the pilot program.

The groundwater level warning stages were initially developed by the DCID board in conjunction with the Department of Water Resources. Prior to adoption by DCID and approval by the Tehama County Board of Supervisors, the stage criteria were reviewed by the Tehama County AB 3030 Technical Advisory Committee, the Tehama County Environmental Health Department, the State Regional Water Quality Control Board, and by local landowners during and a public meeting.

Overall management of the pilot program was governed by the Deer Creek Water Exchange Pilot Program Water Advisory Committee. Membership for the Water Advisory Committee was solicited through public meetings and notices, and ultimately consisted of six to eight local, county and state representatives. Water Advisory Committee (WAC) met monthly during the pilot program to evaluate the existing pilot well operations and monitoring data, determine future operations schedule, make decisions regarding issues of noncompliance, and provide recommendations for possible future programs. Further discussion of the WAC is provided later in this report.

Groundwater Level Monitoring Grids:
Groundwater level monitoring was divided into local and regional monitoring grids. The regional grid covers much of the Stanford Vina Ranch Irrigation Company and consists of 19 agricultural wells, 12 domestic wells and 2 industrial wells. These wells range in depth from 100 to 500 feet and represent groundwater levels associated with the upper to middle portions of the Tuscan aquifer. Figure 8 shows the regional groundwater monitoring grid for the project area.

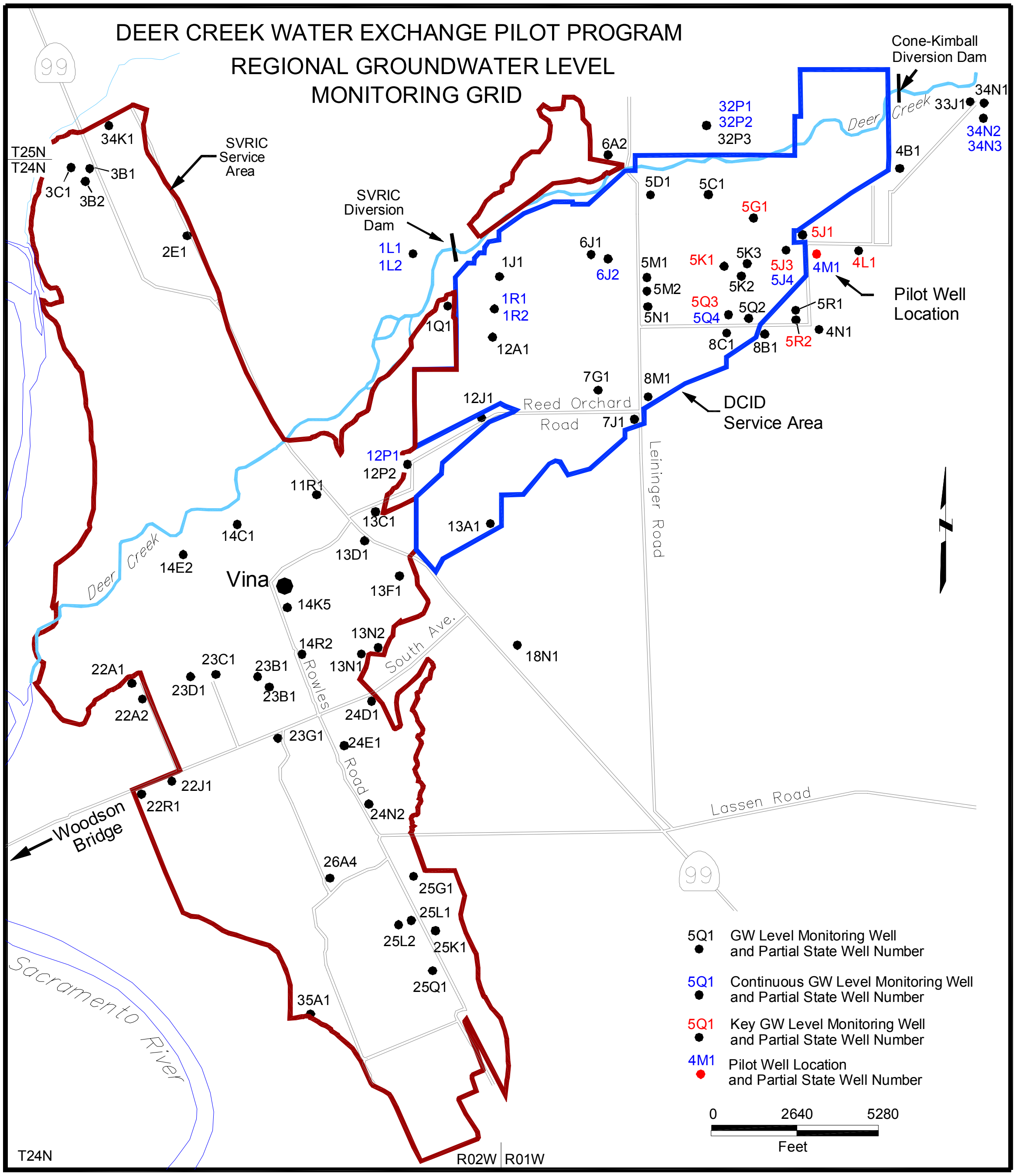


Figure 8. Regional Groundwater Level Monitoring Grid

The local groundwater level monitoring grid covers approximately a 2-mile radius surrounding the pilot well. The local grid includes 16 domestic wells, 12 irrigation wells, and eight multi-completion monitoring wells. The multi-completion monitoring wells were installed as part of an earlier phase of the water exchange program and were constructed as a nested set of wells, to monitor the middle and lower portions of the Tuscan aquifer. Seven of the local wells closest to the pilot well were selected as “key wells” and were used to evaluate potential groundwater level impacts in the middle to upper portions of the Tuscan aquifer and compliance with the groundwater level criteria. Figure 9 shows the location of the Key Monitoring Wells and Key Water Quality sampling locations.

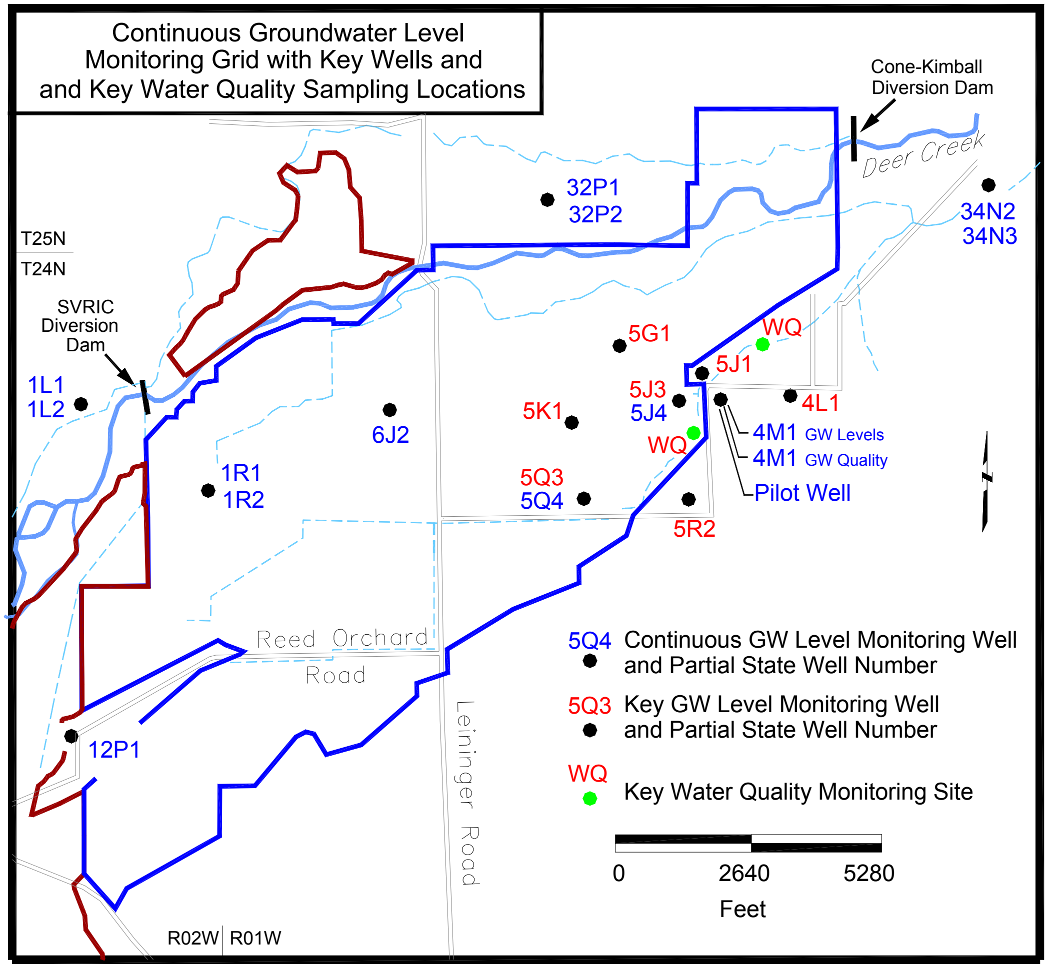


Figure 9. Local "Key Well" Monitoring Grid.

Key well construction and use information is provided below in Table 3. Well construction data in Table 3 shows that the groundwater level monitoring of the key wells allows evaluation of groundwater levels over a wide range of the upper to middle portions of the Tuscan aquifer, from 58 to 520 feet.

State Well Number	Distance from Pilot Well (ft)	Well Use	Aquifer Production Zone	Total Depth (feet)	Perforation Interval (feet)
24N01W-05J03	375	Monitoring Well	Upper Tuscan	385	271-385
24N01W-05J01	390	Cemetery Well	Upper Tuscan	178	58-178
24N01W-04L01	1280	Idle Irrigation	Middle Tuscan	526	117-520
24N01W-05G01	1823	Idle Irrigation	Middle Tuscan	490	130-490
24N01W-05R02	2120	Domestic	Upper Tuscan	160	118-160
24N01W-05K01	2730	Idle Irrigation	Upper Tuscan	260	27-260
24N01W-05Q03	3200	Monitoring Well	Middle Tuscan	415	280-415

Table 3. Key Monitoring Wells, Construction and Use.

Groundwater level fluctuations within the lower Tuscan aquifer were monitored using the deep-zone of the dedicated multi-completion monitoring wells. Construction of the deep aquifer wells is shown in Table 4.

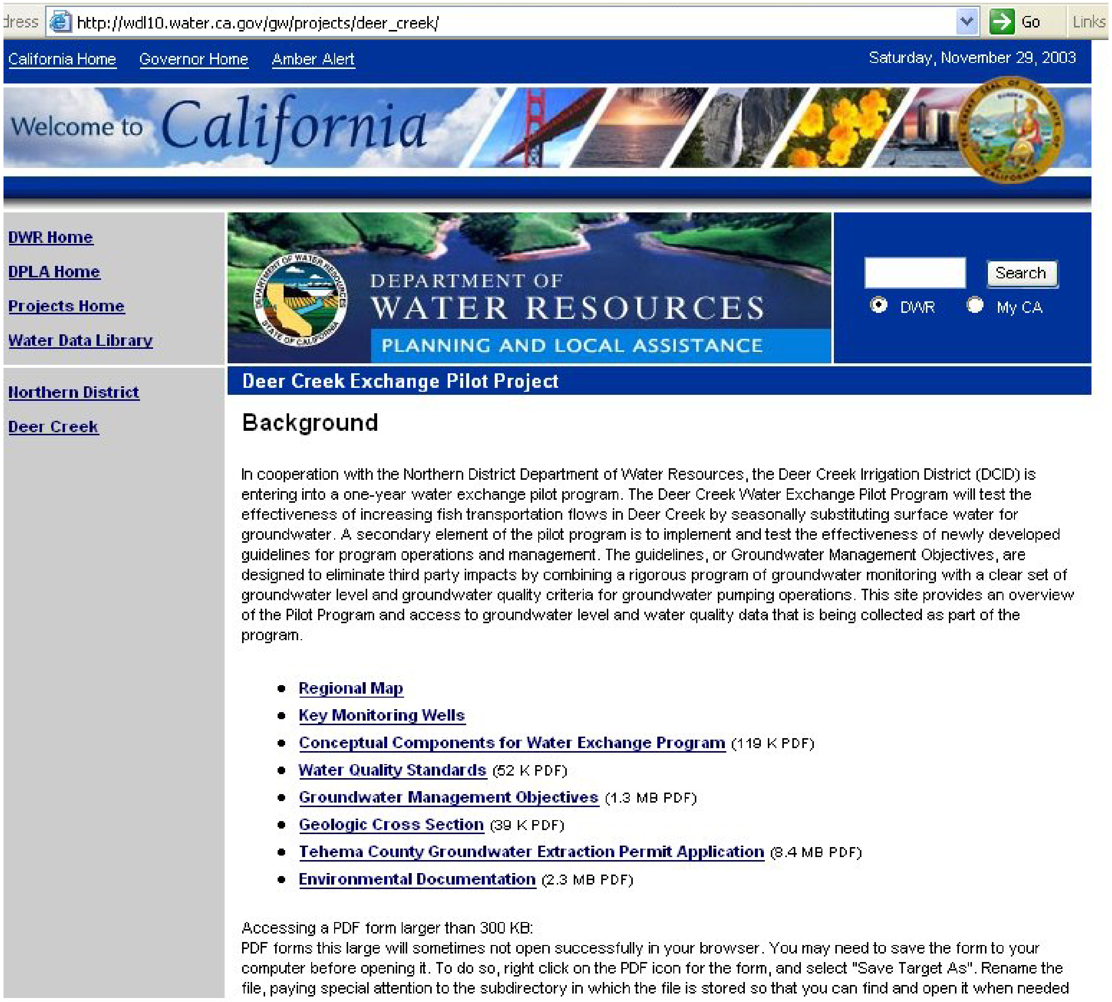
State Well Number	Distance from Pilot Well (ft)	Well Use	Aquifer Production Zone	Total Depth (feet)	Perforation Interval (feet)
24N01W-05J04	375	Monitoring Well	Lower Tuscan	760'	650-722'
24N01W-05Q04	3200	Monitoring Well	Lower Tuscan	840'	700-790'
25N01W-32P04	5,180	Monitoring Well	Lower Tuscan	720'	640-720'
25N01W-34N03	6,930	Monitoring Well	Lower Tuscan	743'	468-743'
24N02W-01R02	9,960	Monitoring Well	Lower Tuscan	880'	765-880'
25N02W-01L02	12,480	Monitoring Well	Lower Tuscan	900'	660-900'
24N02W-12P02	14,070	Monitoring Well	Lower Tuscan	900	560-900'

Table 4. Deep Aquifer Monitoring Well Construction.

Geologic plan-view and cross-sectional maps are provided in Appendix B. The vertical distribution and construction of wells in the project area are illustrated in the geologic cross-section B-B, shown in Figure 4, Appendix B.

Groundwater Level Monitoring Schedule:
The frequency of groundwater level monitoring varied according to the monitoring well location and type, and the program operation schedule. During pilot program operations, the depth to groundwater was measured in the Deer Creek monitoring wells, east of Highway 99, at a frequency of two times per month between April and October. The depth to groundwater in these wells was measured using a steel tape or a battery operated water level meter. Within the localized grid, the seven key wells and all but two of the remaining dedicated monitoring wells within the Deer Creek monitoring grid were equipped with automated groundwater level recording equipment (dataloggers). The dataloggers were set to measure groundwater levels at a minimum frequency of twelve times per day. The groundwater level data stored in the dataloggers were downloaded every week for the first three-weeks of operation, then two times per month between April and October.

Groundwater Level Monitoring Results:
The results of the groundwater level monitoring were provided to the WAC and the Tehama County Flood Control and Water Conservation Board on monthly basis. Distribution of the groundwater level data was also made available to the general public over the Internet, through the Department of Water Resources web sites. Groundwater level data for wells without dataloggers were provided via DWR's Water Data Library web site at: http://wdl.water.ca.gov. Groundwater level data from key wells equipped with dataloggers required construction of a separate database and web site to distribute the information. The continuous groundwater level data associated with the key wells were provided via the Deer Creek Water Exchange Pilot Project web page at: http://wdl10.water.ca.gov/gw/projects/deer_creek/. In addition to the groundwater level monitoring results, the pilot program web page contained project background information, water quality data, well production data, and permitting information. A copy of the pilot program web page is shown in Figure 10.



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Northern District
Deer Creek

Deer Creek Exchange Pilot Project

Background

In cooperation with the Northern District Department of Water Resources, the Deer Creek Irrigation District (DCID) is entering into a one-year water exchange pilot program. The Deer Creek Water Exchange Pilot Program will test the effectiveness of increasing fish transportation flows in Deer Creek by seasonally substituting surface water for groundwater. A secondary element of the pilot program is to implement and test the effectiveness of newly developed guidelines for program operations and management. The guidelines, or Groundwater Management Objectives, are designed to eliminate third party impacts by combining a rigorous program of groundwater monitoring with a clear set of groundwater level and groundwater quality criteria for groundwater pumping operations. This site provides an overview of the Pilot Program and access to groundwater level and water quality data that is being collected as part of the program.

- Regional Map
- Key Monitoring Wells
- Conceptual Components for Water Exchange Program (119 K PDF)
- Water Quality Standards (52 K PDF)
- Groundwater Management Objectives (1.3 MB PDF)
- Geologic Cross Section (39 K PDF)
- Tehema County Groundwater Extraction Permit Application (8.4 MB PDF)
- Environmental Documentation (2.3 MB PDF)

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PDF forms this large will sometimes not open successfully in your browser. You may need to save the form to your computer before opening it. To do so, right click on the PDF icon for the form, and select "Save Target As". Rename the file, paying special attention to the subdirectory in which the file is stored so that you can find and open it when needed

Figure 10. Deer Creek Water Exchange Pilot Program Web Page.

Pilot Well Results: The results of groundwater level monitoring in the pilot well are illustrated in the hydrograph shown in Figure 11. In addition to showing the change in groundwater levels over time, arrows and labels along the top of the hydrograph indicate the operating and non-operating intervals for the pilot well. Figure 11 shows that groundwater levels in the pilot well prior to program pumping were approximately 92 feet below ground surface. During periods of pumping, groundwater levels in the pilot well quickly reach equilibrium with the aquifer after a drawdown of 80 feet, or a depth of 172 feet below ground surface. Groundwater levels remained stable throughout the program pumping, indicating that aquifer properties of transmissivity and storage were adequate for the existing rate of groundwater extraction, and no mining of the aquifer was taking place. Groundwater level recovery in the pilot well at the termination of pumping was rapid, with 96 percent recovery occurring within eight hours. Groundwater levels continued to recover over next 7-days until stabilizing at 94-feet below ground surface; 2-feet lower than the initial spring levels prior to pumping. The 2-feet drop in static groundwater level in the lower Tuscan aquifer between pre and post program pumping could be attributed to normal seasonal fluctuation associated with reduced summer recharge, or could be representative of the volume of the aquifer dewatered as the result of program pumping. Continued monitoring of the pilot well over several seasons should help to characterize the fluctuation.

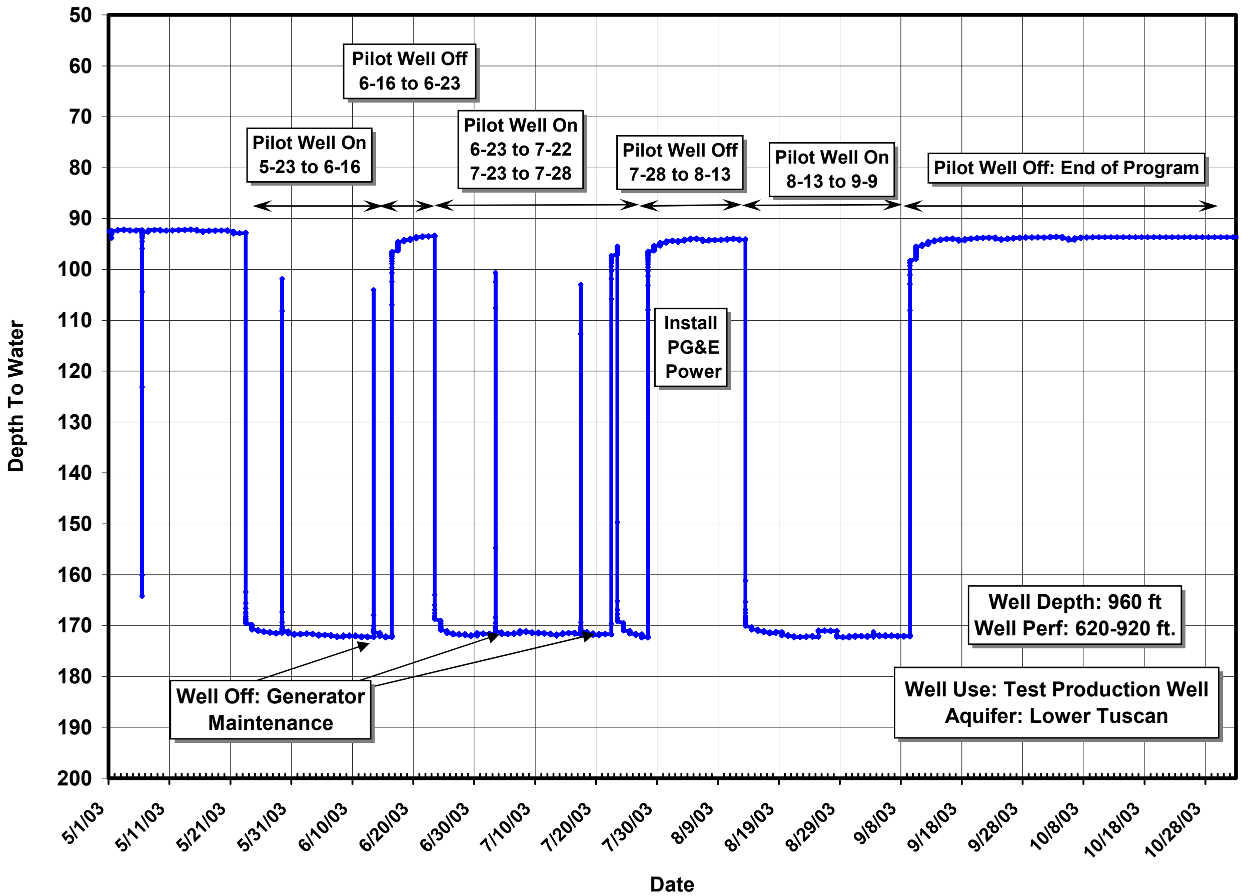

Figure 11. Groundwater Level Hydrograph for the Pilot Well

Key Well Results --Upper to Middle Aquifer Monitoring: The results of groundwater level monitoring of the key wells are illustrated in the hydrographs in Figures 1 through 14, Appendix C. To help with analysis, groundwater level data from the key wells were used to develop two hydrographs for each well, one showing the yearly, or long-term, fluctuation in groundwater levels and one showing monthly changes during the 2003 pilot program.

In the spring of 2003 precipitation continued through the middle of May when an abrupt change in weather conditions resulted in temperatures rising to the high 90's to low 100's. The rapid shift in weather resulted in a rapid shift in evapotranspiration and the subsequent increased demand in agricultural groundwater use. Groundwater levels in many of the monitoring wells in the project area, as well as throughout the valley, showed an abrupt 2 to 3-foot drop, after what had been a period of stable water levels throughout the late spring. The start of the pilot well was triggered by DCID's need for water; consequently, pilot well pumping was initiated during this same late May period. Care should be taken when analyzing the hydrographs to examine groundwater level fluctuations over the entire pilot program, so as not to misinterpret and correlated this initial drop in groundwater levels with the start of the pilot program pumping. Overall results from the groundwater level monitoring of the key wells within the upper to middle portion of the Tuscan aquifer indicates no groundwater level impacts due to pilot well pumping. A short interpretation of each of the key well hydrographs is provided below.

Table 3 lists the seven key wells, their distance from the pilot well and their construction. Figure 9 shows the plan-view distribution of the key wells and Figure 4, Appendix B shows the vertical distribution of the wells within the aquifer.

Key Well 24N01W-05J03: Key well 24N 01W-5J03 is a dedicated monitoring well and is the closest of key wells to the pilot well at a distance of 375 feet. It was installed in 1999 as the shallow well in a nested set of two monitoring wells installed within the same borehole. Well 5J3 is constructed to monitor the upper to middle Tuscan aquifer between 271 and 385 feet. The hydrographs for 5J3 are shown in Figures 5 and 6, Appendix C. Well 5J3 has been equipped with a groundwater level datalogger since 1999. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. Human error in the initial setup resulted in the datalogger being off during the first six days of the pilot well pumping. Interpretation of the groundwater levels during this time is shown as a straight line between the two closest measurements. The three groundwater level warning stages for 5J3 were set at depths of 97, 100 and 103 feet below ground surface.

The long-term hydrograph for 5J3 shows that spring groundwater levels have ranged from 85 to 87 feet since 1999. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet, with temporary declines of 2 to 5 feet when nearby irrigation wells pump for agricultural beneficial use.

The short-term hydrograph for 5J3 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows a 2 to 3 foot drop in groundwater levels near the beginning of the pilot program due to the abrupt change in seasonal evapotranspiration and local groundwater demand. An expanded comparison of pilot well pumping periods and the fluctuation of groundwater levels in 5J3 indicate no apparent correlation. The temporary decline in groundwater levels (approximately 40-hours, 8am on day 1 to 11pm on day two), shown as a series of uniformly spaced downward spikes, are attributed to groundwater pumping of 5K2 (see Figure 8). Well 5K2 is an active agricultural well that supplies water for walnut orchards via a micro-sprinkler delivery system and a fairly uniform irrigation schedule. Overall, groundwater levels in 5J3 remained relatively stable throughout the program.

Key Well 24N01W-05J01: Key well 24N 01W-05J01 is an active well located in the cemetery at a distance of about 390 feet from the pilot well. The well is used for cemetery landscape irrigation and produces water from the upper Tuscan aquifer between 58 and 178 feet. The hydrographs for 5J1 are shown in Figures 3 and 4, Appendix C. Groundwater levels in 5J1 have been monitored since the early 1970's and were equipped with a groundwater level datalogger in May, 2003. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. The three groundwater level warning stages for 5J3 were based on static groundwater levels and set at depths of 38, 42 and 45 feet below ground surface.

The long-term hydrograph for 5J1 shows that static spring groundwater levels have historically fluctuated between 25 and 35 feet below ground surface. During 1976, several pumping water levels were recorded between 46 and 49 feet below ground surface. Seasonally, static groundwater levels fluctuate on an average of 2 to 5 feet.

The short-term hydrograph for 5J1 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows that static groundwater levels remain very stable throughout the pilot program, with depths to water ranging between 28 and 30 feet below ground surface. Closer examination of the hydrograph for 5J1 shows several trends in the pattern of temporary groundwater level drawdown. The series of groundwater levels in the 40 to 50 foot range are associated with periods of pumping within the well 5J1. The series of groundwater levels in the 35-foot range typically occur when 5J1 is not pumping, and are attributed to periods of pumping in nearby agricultural wells. Interesting enough, the short periods of drawdown in 5J1, associated with nearby pumping, do not exactly correspond to the intervals of pumping interference seen in well 5J3. The duration of the drawdown in 5J1 is slightly shorter than 5J3 (30-hours versus 40-hours), and the timing is slightly different (approximately 5pm on day one to 11pm on day two, versus 8am on day one to 11pm on day two).

The hydrographs for 5J1 also show that the all three of the trigger stages for groundwater levels were exceeded during the pilot program. The exceedence of the groundwater level criteria in 5J1 was evaluated by the WAC and, based on the groundwater level hydrographs for 5J1 and the pilot well pumping schedule, the consensus interpretation was that the exceedence of the trigger stages were not associated with pumping of the pilot well. The exceedence of the groundwater level criteria did result in some discussion regarding the methods used to establishing groundwater level trigger stages in active wells. Should the Stages be established based on static or pumping groundwater levels within the well? In the case of 5J1, the stages were selected based on historic static water levels, but in the management criteria, were never clearly explained as being associated with static or pumping levels. This omission resulted in some confusion when pumping levels dropped below the stage criteria. The WAC determined that future programs should be required to clearly address this issue prior to the start of operations.

Key Well 24N01W-04L01: Key well 24N 01W-04L01 is an idle irrigation well located 1,280 feet east of the pilot well. Well 4L1 was drilled and constructed to produce from the upper to middle Tuscan aquifer between 117 and 520 feet, but due to the severe angle of the borehole and casing, the well could not be used for agricultural production. The hydrographs for 4L1 are shown in Figures 1 and 2, Appendix C. Groundwater level monitoring of 4L1 began in 1988. A datalogger was installed for a short time in 2002, and again for the pilot program in May, 2003. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. Groundwater level measurements in the hydrographs are shown as a series of dots; the lines which connect the dots serve as an interpretation of the groundwater levels between the actual measurements. The three groundwater level warning stages for 4L1 were set at depths of 108, 112 and 116 feet below ground surface.

The long-term hydrograph for 4L1 shows that spring groundwater levels range from 80 to 100 feet. Care should be taken when interpreting the groundwater level measurements in this well. Although not indicated in the Figure 1 hydrograph, many of the initial groundwater level measurement were qualified as questionable. Cascading water from a perched water table enters this well through a crack in the casing at about 80-feet. Groundwater level measurements using a steel tape instead of a sounder or datalogger can lead to inaccurate readings. Analysis of the datalogger readings in 2002 and 2003 indicate minimal fluctuation in seasonal groundwater levels.

The short-term hydrograph for 4L1 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows only 1 to 2 foot of fluctuation throughout the pilot well program, and no impacts due to pilot well pumping.

Key Well 24N01W-05G01: Key well 24N 01W-05G01 is and idle irrigation well located 1,823 feet west of the pilot well. Well 5G1 was drilled to produce from the upper to middle portion of the Tuscan aquifer between 130 and 490 feet. Historically, the well has been used for agricultural irrigation. Over the last several years the well has remained idle during removal and replanting of orchard crops. Expectations are that this well will be reactivated for agricultural use in 2004. The hydrographs for 5G1 are shown in Figures 7 and 8, Appendix C. Groundwater level monitoring of 5G1 began in 1998, with dataloggers being used over most of the last three years. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. Error in the initial setup resulted in the datalogger being off during the first six days of the pilot well pumping. Interpretation of the groundwater levels during this time is shown as a straight line between the two closest measurements. The three groundwater level warning stages for 5G1 were set at depths of 88, 92 and 94 feet below ground surface.

The long-term hydrograph for 5G1 shows that spring groundwater levels since 1998 have remained consistent, ranging between 77 and 78 feet below groundwater surface. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet, with temporary declines of 3 to 5 feet when nearby irrigation wells extract groundwater for agricultural beneficial use.

The short-term hydrograph for 5G1 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows a 2 to 3 foot fluctuation in groundwater levels over the 2003 agricultural season and pilot well operating period. The temporary (approximately 40-hours, 8am on day one to 11pm on day two), declines in groundwater levels, shown as a uniformly spaced series of downward spikes, are very similar to the temporary decline seen in 5J3 and are attributed to groundwater pumping of 5K2 (see Figure 8). Overall, groundwater levels in 5G1 remained stable and indicate no impacts associated with pilot well pumping.

Key Well 24N01W-05R02: Key well 24N 01W-05R02 is an active domestic well located 2,120 feet south of the pilot well. The well produces water from the upper Tuscan aquifer between 118 and 160 feet. The hydrographs for 5R2 are shown in Figures 13 and 14, Appendix C. Groundwater levels in 5R2 have been monitored since 1998 and were equipped with a groundwater level datalogger in May, 2003. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. The three groundwater level warning stages for 5R2 were based on static groundwater levels and set at depths of 82, 85 and 90 feet below ground surface.

The long-term hydrograph for 5R2 shows that static spring groundwater levels since 1998 have remained stable, fluctuating between 76 and 78 feet below ground surface. Seasonally, static groundwater levels in 5R2 fluctuate on an average of 2 to 5 feet. Prior to the installation of the datalogger in 2003, no pumping water levels were recorded. Figure 13 shows pumping levels during 2003 ranged between 85 and 90 feet below ground surface.

The short-term hydrograph for 5R2 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows that, other than a short rise in groundwater levels during early June, static groundwater levels remain very stable throughout the pilot program, with depths to water ranging between 79 and 81 feet below ground surface. Closer examination of the hydrograph for 5R2 shows several trends in the pattern of temporary groundwater level drawdown. These trends could be to the result of the pumping schedule of a nearby well, or could be attributed to the variable operation schedule within well 5R2.

The hydrographs for 5R2 also show that groundwater levels dropped below the first two trigger stages. Similar to the situation with 5J1, the consensus interpretation was that the temporary drop in groundwater levels below the two trigger stages was not associated with pumping of the pilot well but due to pumping within 5R2.

Key Well 24N01W-05K01: Key well 24N 01W-05K01 is an idle irrigation well located 2,730 feet west of the pilot well. Well 5K1 was drilled to produce from the upper portion of the Tuscan aquifer between 27 and 260 feet. Obstructions within the well currently prevent it from being used for irrigation. The hydrographs for 5K1 are shown in Figures 9 and 10, Appendix C. Groundwater level monitoring of 5K1 began in 1999, with dataloggers being installed at that time. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. Error in the initial setup resulted in the datalogger being off during the first six days of the pilot well pumping. Interpretation of the groundwater levels during this time is shown as a straight line between the two closest measurements. The three groundwater level warning stages for 5K1 were set at depths of 74, 77 and 80 feet below ground surface.

The long-term hydrograph for 5K1 shows that spring groundwater levels between 1999 and 2002 have averaged about 64-feet below ground surface. In 2003, spring groundwater levels increased to about 61-feet below ground surface. The reason for the groundwater level increase during the first part of 2003 is unknown. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet, with temporary declines of 3 to 5 feet when nearby irrigation wells extract groundwater for agricultural beneficial use.

The short-term hydrograph for 5K1 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows that groundwater levels remain very stable at 61 to 62 feet below ground surface throughout the pilot program. The temporary (approximately 40-hours, 8am day one to 11pm day two), declines in groundwater levels, shown as a uniformly spaced series of downward spikes, are very similar to the temporary declines seen in 5J3 and 5G1, and are attributed to groundwater pumping of 5K2 (see Figure 8).

Key Well 24N01W-5Q03: Key well 24N 01W-5Q03 is a dedicated groundwater level monitoring well located 3,200 feet southwest of the pilot well. It was installed in 1999 as the shallow well in a nested set of two monitoring wells installed at the same location. The well is constructed to monitor the upper to middle Tuscan aquifer between 280 and 415 feet. The hydrographs for 5Q3 are shown in Figures 11 and 12, Appendix C. Well 5Q3 has been equipped with a groundwater level datalogger since 1999. Prior to the pilot program, the datalogger was set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours. Error in the initial setup resulted in the datalogger being off during the first six days of the pilot well pumping. Interpretation of the groundwater levels during this time is shown as a straight line between the two closest measurements. The three groundwater level warning stages for 5Q3 were set at depths of 80, 83 and 87 feet below ground surface.

The long-term hydrograph for 5Q3 shows that spring groundwater levels range from 67 to 69 feet since 1999. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet, with temporary declines of 3 to 6 feet when nearby irrigation wells extract groundwater for agricultural beneficial use.

The short-term hydrograph for 5Q3 illustrates groundwater level fluctuations during pilot program operations, between May and October of 2003. Periods of pilot well pumping are shown on the hydrograph with text boxes and arrows. The short-term hydrograph shows a 2 foot drop in groundwater levels near the beginning of the pilot program due to the rapid increase in evapotranspiration and local groundwater demand. Between June and October, groundwater levels remain relatively stable with fluctuations from 70 to 72 feet, and temporary additional declines of 3 to 6 feet. The temporary (approximately 40-hours, 8am day one to 11pm day two), declines in groundwater levels, shown as a uniformly spaced series of downward spikes, are very similar to the temporary declines seen in 5J3, 5G1 and 5K1, and are attributed to groundwater pumping of 5K2 (see Figure 8).

Lower Tuscan Aquifer Results: Groundwater level monitoring of the lower Tuscan was conducted using the deep dedicated monitoring wells that were installed in 1999. Table 4 lists the deep aquifer monitoring wells, their distance from the pumping well and their construction. Figure 9 shows a plan-view distribution of the wells. The vertical distribution and construction of wells are illustrated in the geologic cross-section B-B, shown in Figure 4, Appendix B. The results of groundwater level monitoring of the lower Tuscan aquifer are illustrated in the hydrographs in Figures 1 through 10, Appendix D. To help with analysis, groundwater level data for deep aquifer wells were used to develop two hydrographs for each well, one showing yearly long-term fluctuations in groundwater levels and one showing monthly changes during the 2003 pilot program. All of the deep aquifer monitoring wells were equipped with dataloggers. Prior to the pilot program, the dataloggers were set to record groundwater levels every 4 to 6 hours. During the pilot program, the datalogger was set to record groundwater levels every 1 to 2 hours.

Overall results from the groundwater level monitoring in the lower Tuscan aquifer indicates drawdown impacts ranging from approximately 16 feet in 5J4 (located 375 feet from the pilot well), to 1.3 feet in 1L2 (located 12,480 feet from the pilot well). Figure 12 is a plan view map showing the lower Tuscan monitoring wells, measured groundwater level impacts in the lower aquifer and interpreted groundwater drawdown contour lines during pilot well pumping. Figure 13 is a graph showing the distance versus drawdown relationship for the lower Tuscan monitoring wells during pilot well pumping. Figures 12 and 13 show that, although the majority of drawdown related impacts to the lower aquifer subside within a distance of 2,000 feet, a small amount of drawdown (~ 1.5 feet) continues outward from the pilot well at distances of about 10,000 feet. A short interpretation of the monitoring data from six of the lower Tuscan wells is provided below.

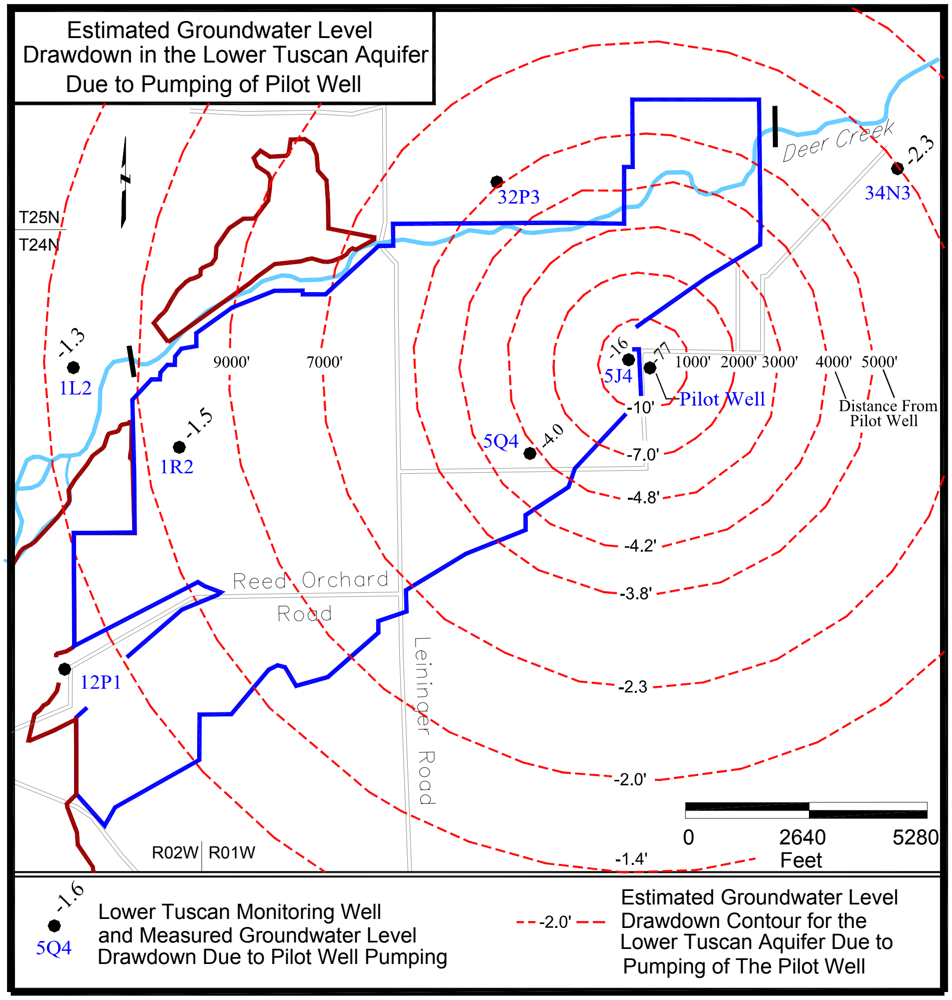

Figure 12. Groundwater Drawdown in the Lower Tuscan Aquifer During Pilot Well Pumping.

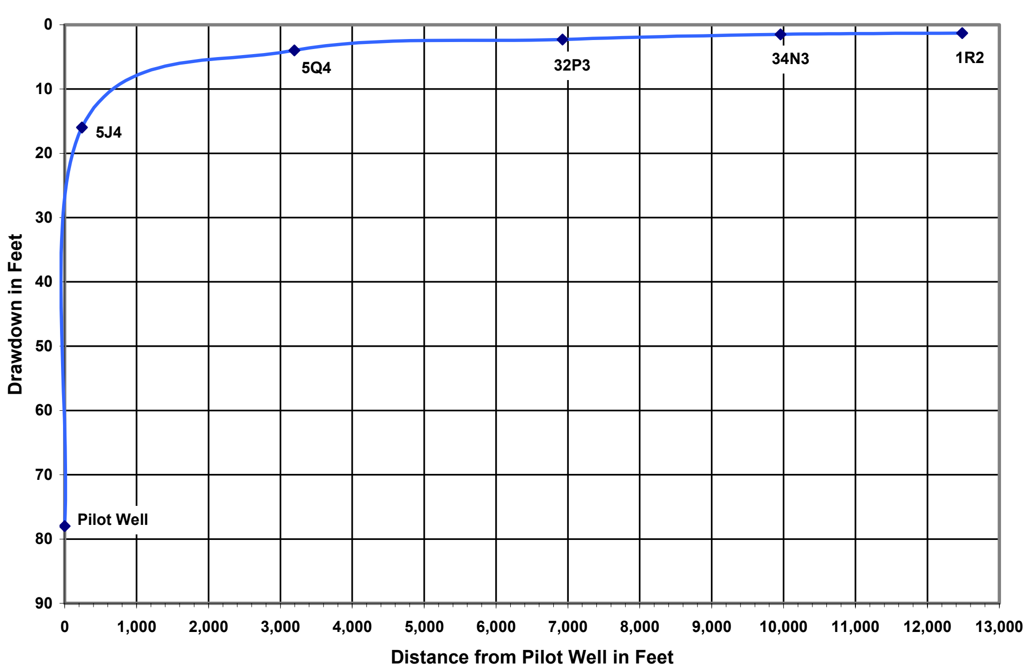

Figure 13. Distance versus Drawdown Curve in the Lower Tuscan Aquifer During Pilot Well Pumping.

Lower Tuscan Well 24N01W-5J04: Key well 24N 01W-5J04 is the closest of lower Tuscan monitoring wells to the pilot well at a distance of 375 feet. Well 5J4 is constructed to monitor the lower Tuscan aquifer between 650 and 722 feet. The hydrographs for 5J4 are shown in Figures 1 and 2, Appendix D. Error in the initial setup resulted in the datalogger in 5J4 being off during the first six days of the pilot well pumping. Interpretation of the groundwater levels during this time is shown as a straight line between the two closest measurements.

The hydrographs for 5J4 shows that spring groundwater levels range from 87 to 89 feet since 2000. Seasonally, groundwater levels fluctuate on an average of 1 to 2 feet between spring and summer, with additional temporary declines of 1 to 2 feet when nearby irrigation wells extract groundwater for agricultural beneficial use. The long-term hydrograph for 5J4 shows a temporary groundwater level decline of 20-foot in early 2003 as the result of pump testing the pilot well at a higher pumping rate than the summer program.

Although the initial drop in groundwater levels associated with the start of the pilot program was not recorded, the short-term hydrograph shows that subsequent operations of the pilot well results in a groundwater level decline of about 16 feet in 5J4 prior to stabilizing at a depth of about 107 feet below ground surface. The short-term hydrograph also show a series of brief upward spikes in the groundwater level between May and August. These brief upward spikes correspond to periods when the diesel motor for the pilot well was temporarily shut down for maintenance.

Close examination of the groundwater level data in the short-term hydrographs shows an additional series of small (0.5 to 1.5 foot) background fluctuations in groundwater levels that begin prior to pilot well operations and continue after the pilot well is shut down. These small fluctuations in groundwater levels are also noticeable during the previous years and are likely due to groundwater pumping for irrigation within the project area.

Lower Tuscan Well 24N01W-5Q04: Key well 24N 01W-5Q04 is a deep dedicated monitoring well located 3,200 feet to the west of the pilot. Well 5Q4 is constructed to monitor the lower Tuscan aquifer between 700 and 790 feet. The hydrographs for 5Q4 are shown in Figures 3 and 4, Appendix D. Error in the initial setup resulted in the datalogger in 5Q4 to be off for five days from May 28th to June 3rd. Interpretation of the groundwater levels during this time is shown as a straight line between the two closest measurements.

The hydrographs for 5Q4 show that spring groundwater levels have ranged from 70 to 72 feet since 2000. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet between spring and summer, with additional temporary declines of 1 to 2 feet when nearby irrigation wells extract groundwater for agricultural beneficial use, and about 4 foot of decline during the operation of the pilot well in 2003. The short-term hydrograph for 5Q4 also shows a series of 1 to 2 foot of groundwater level fluctuation regardless of pilot well operations. These small fluctuations in groundwater levels are also noticeable during the previous years and are likely due to agricultural pumping within the project area.

Lower Tuscan Well 25N01W-34N03: Key well 25N01W-34N03 is a deep dedicated monitoring well located 6,980 feet to the east of the pilot. Well 34N3 is constructed to monitor the lower Tuscan aquifer between 468 and 743 feet. The hydrographs for 34N3 are shown in Figures 5 and 6, Appendix D.

The hydrographs for 34N3 show that spring groundwater levels have ranged from 146 to 148 feet below ground surface since 2000. Seasonally, groundwater levels fluctuate on an average of 1 to 1.5 feet between spring and summer, and declined 2 to 2.5 feet during the operation of the pilot well during the summer of 2003. The short-term hydrograph for 34N3 also shows a daily series of 0.1 foot fluctuations in the groundwater level regardless of pilot well operations. Closer examination indicates that small 0.1 foot fluctuations are likely due to natural external forces and not associated with nearby groundwater pumping.

Lower Tuscan Well 24N02W-01R02: Key well 24N02W-01R02 is a deep dedicated monitoring well located 9,960 feet to the west of the pilot. Well 1R2 is constructed to monitor the lower Tuscan aquifer between 765 and 880 feet. The hydrographs for 1R2 are shown in Figures 7 and 8, Appendix D.

The hydrographs for 1R2 show that spring groundwater levels have ranged from 33 to 35 feet below ground surface since 2000. Seasonally, groundwater levels fluctuate on an average of 2.5 feet between spring and summer, with additional temporary declines of 1 to 3 feet as the result of nearby agricultural groundwater pumping, and declines of about 1.5 feet associated with the pilot well pumping during the summer of 2003.

Lower Tuscan Well 24N02W-01L02: Key well 24N02W-01L02 is a deep dedicated monitoring well located 12,480 feet west of the pilot. Well 1L2 is constructed to monitor the lower Tuscan aquifer between 660 and 900 feet. The hydrographs for 1L2 are shown in Figures 9 and 10, Appendix D.

The hydrographs for 1L2 show that spring groundwater levels have ranged from 37 to 38 feet below ground surface since 2000. Seasonally, groundwater levels fluctuate on an average of 2 to 3 feet between spring and summer, with additional temporary declines approximately 0.5 to 1.0 foot as the result of nearby agricultural groundwater pumping, and declines of about 1.3 foot from pilot well pumping during the summer of 2003.

Water Quality Monitoring and Management

Maintaining a minimum level of acceptable water quality from the pilot program pumping well was the second criteria used to manage program operations. The water quality criteria required that groundwater from the pilot well will be maintained above the recommended water quality goals established by the California Regional Quality Control Board. Operation of the pilot program would proceed as long as there is compliance with these pre-agreed to groundwater quality criteria. A detailed explanation of the pilot program monitoring and management plan is provided in Appendix A. The analytical results of the water quality sampling are listed in Tables 1 through 3, Appendix E. Recommended water quality standards for agriculture and domestic use are listed in Table 4, Appendix E. A summary of the management methods and the results from the water quality monitoring are provided below.

Three key sites were used to monitor water quality compliance. These sites are listed below and shown in Figure 9.

- Site 1: DCID distribution system water, above the point where groundwater from the pilot well discharges into the system.
- Site 2: Pilot well water as it discharges from the pilot well.
- Site 3: DCID distribution system water, below the point where groundwater from the pilot well discharges into the system.

The Department of Water Resources conducted the field collection and testing of surface and groundwater quality samples during the program. Analytical testing was conducted at a State of California approved laboratory and included analysis for minerals, trace metals and nutrients. Minerals analysis included testing for conductivity, pH, temperature, alkalinity, total dissolved solids, total hardness, boron, calcium, chloride, magnesium, potassium, sodium and sulfate. Trace metal analysis included testing for aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium and zinc. Nutrient analysis included testing for ammonia, dissolved orthophosphate, nitrite, nitrate, and total phosphorus.

The proposed water quality monitoring schedule for the three key sites is listed below. The actual monitoring schedule was adjusted somewhat due to unexpected shut-downs of the generator supplying power to the pilot well.

- Once prior to the start of the pilot program pumping (during pump testing),
- Once within 5 days after the start of the pilot program,
- Once every 30-days for subsequent program pumping, and
- Once just prior to the conclusion of the program.

In addition, as part of one of the conditions for the Tehama County Groundwater Extraction Permit, Tehama County requested that field measurements for electrical conductivity be conducted on a weekly basis, while the pilot well was operating. The intent of the request was to closely monitor the salinity of the groundwater being extracted from the pilot well, so as to protect against upward migration of saline waters deep within the aquifer.

Water Quality Monitoring Results: The results of the weekly field monitoring for electrical conductivity (EC) are shown Figure 14 below, and listed in Table 1, Appendix A. Figure 14 shows that the EC in the pilot well remained stable and of high quality throughout the program, with an average EC of 146 microseimens per liter. Electrical conductivity readings taken in the DCID canal, upstream of the pilot well, were somewhat lower, averaging 130 microseimens.

Water temperature from the pilot well averaged 64 degrees Fahrenheit with a variation of only 1.5 degrees throughout the program. Temperatures in the DCID canal, upstream of the pilot well discharge, remained slightly higher than the pumping well with an average of 66 degrees Fahrenheit. Temperatures in the canal also increased slightly through the summer.

Water Quality samples for minerals were collected from the pilot well during the testing of the pilot well in February 2003. Additional samples were collected from the pilot well and in the DCID canal upstream and downstream of the pilot well during each of the three extended program pumping periods. The results of the analytical testing for minerals are provided in Table 2, Appendix E. The mineral results from all sample locations and times show that the waters are of high quality, and concentration of mineral constituents are well within the recommended standards for agricultural or domestic use.

Water Quality samples for metals and nutrients were collected at the same times and locations as the mineral samples. The results of the analytical testing for metals and nutrients are provided in Table 3, Appendix E. The analytical results from all of the sample locations and times show that the waters are of high quality and concentration of metals and nutrient are well within the recommended standards for agricultural or domestic use.

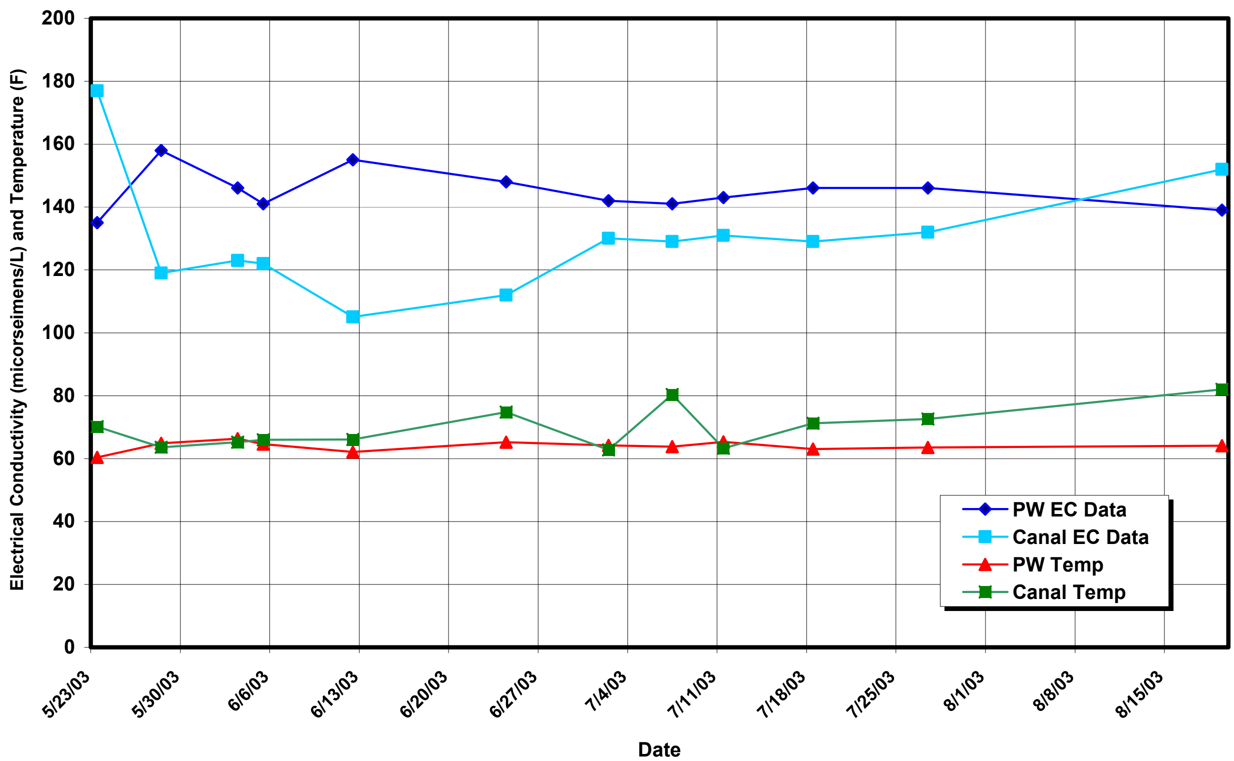

Figure 14. Results of Field Monitoring for Electrical Conductivity and Temperature in the Pilot Well and the DCID Canal

Surface Water Monitoring

The primary focus of the 2003 pilot program was to ascertain groundwater level and water quality related impacts associated with pumping from the lower Tuscan aquifer with the test production pilot well. Monitoring and controlling DCID's surface water diversion and implementation of a small-scale water exchange was not the primary intent of the 2003 program. However, if an expanded program were to be implemented in the future, monitoring and control of DCID's surface water diversion and monitoring of the fish transportation flow in Deer Creek, would be an important part of the program's management and operations. In preparation for future programs, active monitoring of DCID's diversion and the flow in Deer Creek was conducted during the 2003 pilot program. A summary of surface monitoring aspects of the pilot program is presented below. Surface water flow data is provided in Figures 1 through 8, Appendix F.

Surface water flow was in Deer Creek was monitored using the USGS gaging station (No. 11383500; *Deer Creek Near Vina*). The USGS gage records flow and stage at 15-minute intervals and is located approximately 0.5 miles upstream from the Deer Creek Diversion in the northeast one-quarter of section 23, township 25N, range 01W. DCID's diversion of Deer Creek water was monitored by DWR and DCID using an 8-foot parshall flume located just below DCID's Deer Creek diversion structure. The parshall flume is equipped with a continuous data-recorder which is downloaded every two-months. The location of the USGS and DCID surface water monitoring locations are shown in Figure 15.

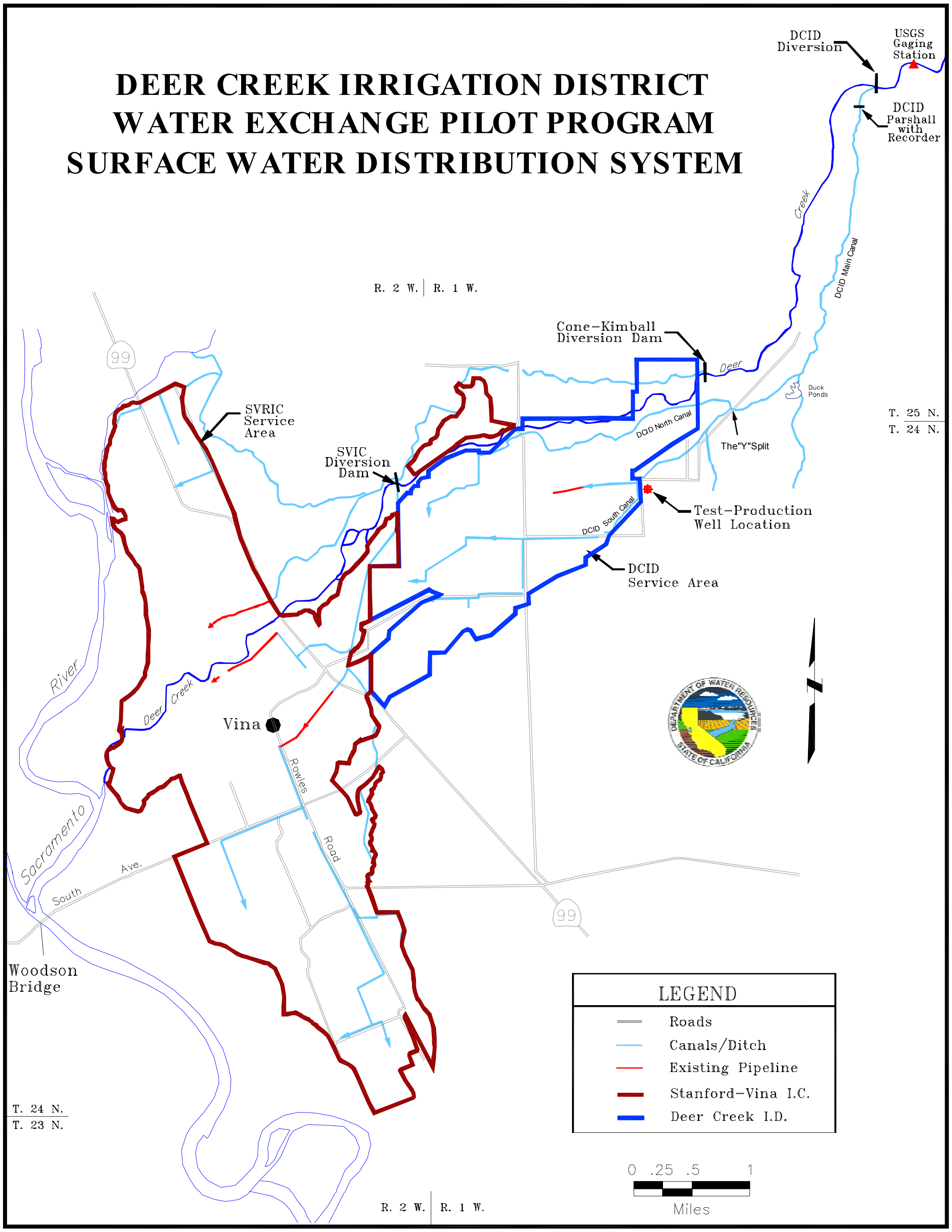

Figure 15. Deer Creek Surface Water Distribution System

DCID diversion data for 2003 is presented in Table 5. Table 5 shows the minimum, maximum and average daily DCID diversion between April and September of 2003. Vandalism of the data-recorder at the diversion resulted in DCID's April and May diversion data being lost. Consequently, DCID's surface water diversion in Table 5 for April and May were estimated, and are based on the average of previous years for these months. Table 5 shows that the maximum average daily diversion averages 35 cfs.

DCID Diversion: During 2003 Pilot Program					
Month	Ave. Daily Diversion (cfs)			Aver. Monthly Totals	
	Min.	Max.	Ave.	(cfs)	(ac-ft)
Apr.	15*	38*	32*	960*	1,200*
May	24*	37*	20*	605*	1,900*
Jun.	24	35	29	759	1,503
Jul.	26	35	29	906	1,794
Aug.	30	36	33	1,035	2,049
Sep.	32	34	33	993	1,966
			Total =	**5,258***	**10,412***
* Estimated Values					

Table 5. DCID Diversion of Deer Creek Water; April – September, 2003

The 2003 average daily flow in Deer Creek, as measured at the USGS gage, along with the average daily DCID diversion are shown in Figure 16. Even though 2003 experienced a wet spring, Figure 16 illustrates the flows in Deer Creek can drop substantially between late spring and early summer. Monthly charts illustrating Deer Creek Flow versus DCID Diversion are provided in Appendix F.

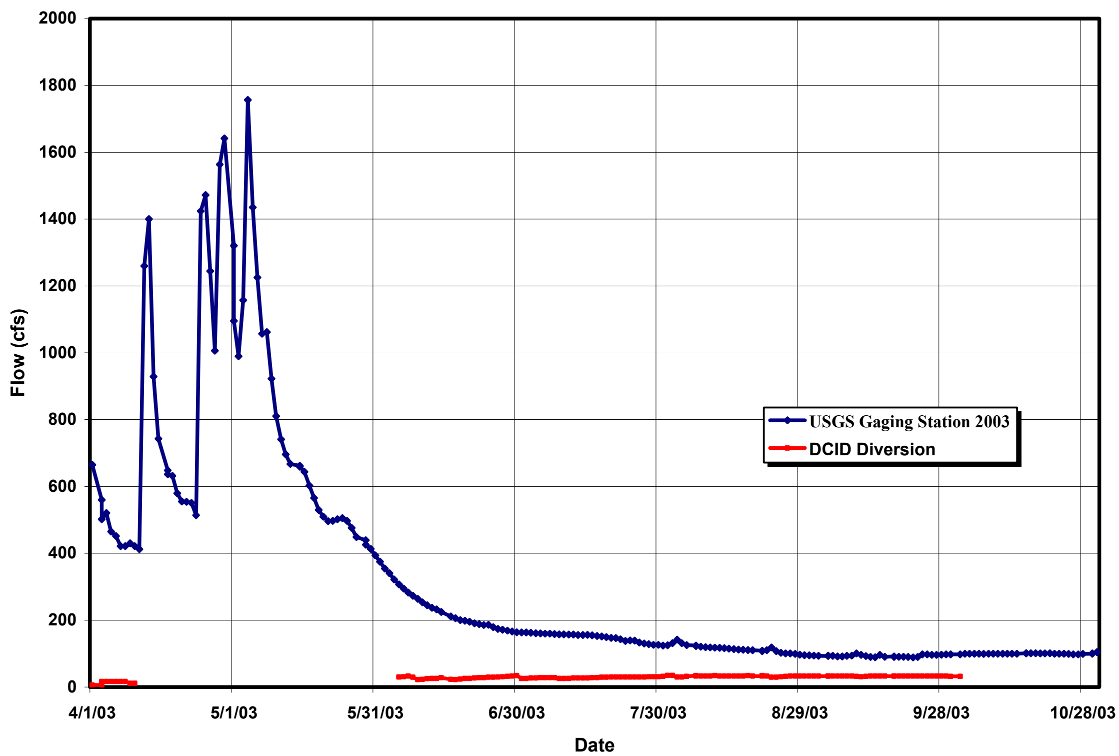

Figure 16. Deer Creek Average Daily Flow at USGS Gage and DCID Diversion during 2003 Pilot Program.

PILOT PROGRAM COSTS

The costs associated with the pilot program were divided into well construction costs and program operating costs. A detailed breakdown of the construction costs of the pilot well are listed in Table 6.

Deer Creek Pilot Well Drilling, Installation, Development & Power Costs		
WELL DRILLING & CONSTRUCTION		**Costs**
Mobilization of drilling equipment to drilling site		$10,500
Reverse rotary drilling 28' Borehole		$102,720
Run Geophysical logs as specified		$2,640
Supply & install 16" i.d. x .312 wall Blank Collared Casing		$12,880
Supply & install 16" i.d. x .375 wall Blank Collared Casing		$7,700
Supply & install 16" i.d. x .312 wall FUL-FLO Perforation (.090 slot)		$26,260
Supply & install 2" SCH 40 Access tube		$2,136
Supply & install 3" SCH 40 Access tube		$2,400
Supply & install SRI #6 gravel pack		$7,898
Supply & install cement sanitary seal		$9,555
Pull out rig and trailers		$2,392
WELL DEVELOPMENT & TESTING	**Subtotal:**	**$187,080**
Installation and Removal of Test Pump		$3,800
Conduct Well Development Pumping		$1,875
Conduct Step-Drawdown Pump Test		$1,350
Conduct Constant Discharge Test		$7,200
PUMP INSTALLATION AND TEMP WORK	**Subtotal:**	**$14,225**
Turbine Pump --Water Lubricated		$30,760
Sole Plate Mounted on Well		$575
Pump installation Labor		$1,600
Pump Discharge Assembly		$1,975
Discharge Assembly Installation		$1,350
Temporary Pump Discharge Materials		$725
Temporary Pump Discharge Installation		$1,170
POWER INSTALLATION COSTS	**Subtotal:**	**$38,155**
Payment to PG&E for power to well		$1,140
Payment to PG&E for overhead extension		$10,845
Electrical Service with Soft Start Panel		$11,944
Backhoe excavate trench for PG&E		$700
DISHCARGE STRUCTURE AND ASSOCIATED WORK:	**Subtotal:**	**$24,629**
Backhoe excavate trench for PG&E		$5,310
Well discharge structure 90" x 42"		$2,782
Exposed 12" line, excavated and placed out flow box		$924
MISC. SUPPLIES & WORK:	**Subtotal:**	**$9,015**
Straw (runoff control)		$517
Roadbase Gravel		$3,770
Shed Installation and Cow Protection Panels		$5,100
	Subtotal:	**$9,387**
	TOTAL:	**$282,491**

Table 6. Pilot Well Drilling and Installation Costs

The pilot well costs listed in Table 6 do not include expenses associated with pre-drilling activities such as, site evaluation, CEQA permitting, temporary access permits, easement acquisition, or costs associated with oversight of pilot well drilling, construction, development and performance testing.

The estimated future operating costs of the pilot well are listed in Table 7. The cost breakdown is based on program operations in 2003, and includes costs associated with monitoring and permitting, as well as the energy costs to operate the pump.

GW Level Monitoring	**Days**	**Hours**	**Hr Rate**	**Cost**
Measurement & Downloading	20	160	$80	$12,800
Compile and Reporting	5	40	$80	$3,200
			Subtotal:	$16,000
Water Quality Monitoring	**Days**	**Hours**	**Hr Rate**	**Cost**
Sample Collection	3	12	$80	$960
Lab Analysis	9		$120	$1,080
Compile and Reporting	1	8	$80	$640
			Subtotal:	$2,680
Surface Water Mont.& Maint.	**Days**	**Hours**	**Hr Rate**	**Cost**
DCID Parshall (annual costs)	12	96	$80	**$7,680**
Permiting	**Days**	**Hours**	**Hr Rate**	**Cost**
TC Permitting	6	48	$80	$3,840
CEQA Permitting	3	24	$80	$1,920
			Subtotal:	$5,760
Program Management	**Days**	**Hours**	**Hr Rate**	**Cost**
General Management/Oversight:	20	160	$80	$12,800
Reporting, Meetings, etc	15	120	$80	$9,600
			Subtotal:	$22,400
Pilot Well Energy Costs	**Days**	**Acre-Ft**	**$/kwhr**	**Cost**
Electricity (assume 258 kwhr/af)	60	331	$0.17	$14,518
Six-Month Demand Charge				$1,188
			Subtotal:	$15,706
ESTIMATED TOTAL ANNUAL OPERATING COST:				**$70,226**
Note: Above cost estimates are based on: - Monitoring Program Remaining Consistent with Existing Plan. - Production well operating under PG&E AG-4A Rate structure. - Pilot well operating at 1,250 gpm, overall efficiency of 72% and total head of 172 ft.				

Table 7. Estimated Future Operation Costs for the Pilot Well.

Due to delays connecting to PG&E power, the 2003 pilot well program also included costs associated with the operation and rental of a diesel generator for two months. It was assumed that these costs would not be applicable to future programs and they are not included in Table 7.

As future pumping programs progress, additional groundwater level and water quality data is collected, and more confidence is gained with respect to affects of the pilot well pumping, some reduction in the frequency and amount of groundwater level and water quality sampling may be appropriate. Reductions in these areas may help reduce the cost of future program operations.

WATER ADVISORY COMMITTEE

As part of the Deer Creek Water Exchange Pilot Program a Water Advisory Committee (WAC) was formed. The duties of the WAC were to help oversee pilot program operations and compliance, interface with the local, county and state representatives, and provide recommendations for future program operations. Solicitations to serve on the WAC were mailed to all the DCID and SVRIC membership, and presented at several public meetings. Ultimately, the WAC consisted of groundwater and surface water users within the DCID service area, and representatives from Tehama County Department of Environmental Health, Tehama County Flood Control & Water Conservation District, University of California Cooperative Extension, DCID, DWR and CDFG.

Beginning in June, WAC meetings were held once a month during program operations. Several additional meetings were held after the end of program pumping to discuss findings, review the end of program report, provide recommendations for possible future programs and examine potential sources of funding for future programs. At the request of the WAC, representatives from the California Bay Delta Water Authority Environmental Water Program, the Water Use Efficiency Program and the Sacramento Valley Water Management Program attended a WAC meeting and provided information as to future funding opportunities under each program. One of the outcomes of the meetings was the development of a list of operational goals, or conceptual components, for future expansion of the pilot program into a comprehensive agreement that will help secure a reliable source of water for future domestic, agricultural and environmental beneficial use. These goals were presented, along with a background introduction of the origin of the pilot water exchange program, for comment at a public meeting and were ultimately approved by the DCID Board as a recognized framework to begin development of a future water exchange program. The *Conceptual Components for a Deer Creek Water Exchange Program* document that was circulated for public comment is provided below.

CONCEPTUAL COMPONENTS FOR A DEER CREEK
WATER EXCHANGE PROGRAM
November, 2003

A proposal to implement a Water Exchange Program for the lower Deer Creek area is being developed and input is being requested. The following document outlines the background of the proposed program and presents a conceptual draft of components that could be included in the program proposal. The purpose of this document is to encourage discussion, participation and feedback as to program development. The final proposal will encourage the participation by both Deer Creek Irrigation District and Stanford Vina Ranch Irrigation Company, incorporate the needs of local water users, follow the appropriate permitting requirements, and be integrated with existing federal, state and local programs.

Background:

In 1923 the courts adjudicated entire flow of Deer Creek with 35% of the flow entitlement going to Deer Creek Irrigation District and 65% to Stanford Vina Ranch Irrigation Company.

In 1989, the Resources Agency published a report entitled: *Upper Sacramento River Fisheries and Riparian Habitat Management Plan*. Findings from the plan concluded that Deer Creek is one of only a few waterways in the Central Valley that continues to support a native population of wild spring-run Chinook salmon and the most serious impact to the Deer Creek fishery is the reduction of transportation flows. The 1989 plan identified the number one solution to increasing transportation flows was to negotiate an agreement with water right holders to pump groundwater into the irrigation systems at critical times in exchange for leaving an equal amount of natural flow in the stream for fish migration.

In 1993, California Department of Fish and Game published a report entitled: *Restoring Central Valley Streams: A Plan for Action*. Findings from this study concluded that Deer Creek has the greatest potential of all Sacramento Valley streams for increasing naturally spawning population of steelhead and spring-run salmon.

Although both the 1989 and 1993 studies agreed that the exact amount of flow necessary to provide unimpaired migration for adult salmon and steelhead is unknown, an estimated flow requirement of approximately 50 cfs, as measured below the Stanford Vina Ranch Irrigation Company main diversion, was identified.

In 1998, Deer Creek Watershed Conservancy implemented the *Deer Creek Watershed Management Plan*. As part of the plan, the DCWC adopted several recommendations from the 1989 and 1993 studies, and incorporated as their number one strategy to maintain stream flows necessary for unimpaired fish passage for Chinook salmon and steelhead.

Since 1994, DCID and SVRIC have worked with state, county and local groups to identify their agricultural water needs and study various scenarios to increase fish transportation flows in Deer Creek. In 1998 a parshall flume was constructed along DCID's diversion to help identify DCID's seasonal diversion requirements. In 1998 and 1999, several dedicated groundwater monitoring wells were constructed and a comprehensive groundwater monitoring program was developed in the lower Deer Creek watershed. In 2002 a test production well was constructed in the lower aquifer and in 2003, DCID along with DWR and Tehama County, participated in a Deer Creek Water Exchange Pilot Program. The Pilot Program tested the effectiveness of increasing the fish transportation flows in Deer Creek by seasonally substituting bypassed surface water for groundwater, while minimizing third-party impacts associated with pumping.

Conceptual Components of a Proposed Water Exchange Program

DCID recognizes the need for a long-term solution to the fisheries issue in Deer Creek and is providing draft proposal of conceptual components that they feel are necessary for the successful implementation of a water exchange program, and the successful implementation of the goals set forth by the Deer Creek Watershed Management Plan, along with state and federal fisheries restoration plans.

As mentioned, the estimated flow for unimpaired fish migration has been identified at 50 cfs. With a 35% entitlement to Deer Creek flow, DCID's proposed contribution is estimated at 17 cfs. DCID has undertaken a preliminarily evaluation of the key components, necessary to achieve their bypass goal of 17 cfs, without significant adverse affects to agriculture and environmental water needs, and local groundwater users. A draft list of these components is as follows:

- **Efficiency Improvements to the DCID Distribution System:** Efficiency improvements to the distribution system may include piping, canal lining, weirs and SCADA system. A secondary element of this component may be on farm conservation and efficiency improvements such as soil moisture monitoring, land leveling, recirculation, etc. Prior to establishing an estimated cost for this component, a detailed evaluation of the DCID distribution systems will be necessary.

- **Supplemental Water Supply Development:** Supplemental water supply may be developed through groundwater substitution pumping. Completion of the Deer Creek Water Exchange Pilot Program in 2003 has shown that the lower portion of the underlying aquifer may be pumped without impacts to upper aquifer users. Continuation of this pilot program will evaluate impacts of groundwater extraction from the lower aquifer under different climatic and hydrologic conditions, particularly in a drought scenario. The use of existing agricultural wells to provide supplemental water may be a less expensive alternative than the construction of additional wells in the DCID service areas. However, the availability of existing agricultural wells that extract groundwater primarily from the lower aquifer and prevent impact to upper aquifer users will need to be explored. A secondary element of this component could look at opportunities for aquifer recharge.

- **Surface and Groundwater Monitoring:** Prior to augmenting supply through groundwater substitution pumping, groundwater management objectives would be defined and a monitoring plan suitable for fulfilling the objectives would be adopted. Surface water flow monitoring will be necessary both instream and within the District's distribution system to quantify program benefits. Water quality monitoring would be conducted as necessary to identify potential water quality-related impacts associated with groundwater pumping.

- **Fish Migration Monitoring**. CDF&G and USFWS would develop a monitoring program to measure improvements in fisheries habitat and migration of fish, specifically spring-run salmon and steelhead.

- **Long-term Lease of Bypassed Water:** An agreement would be worked out to develop a long-term lease of the Deer Creek water bypassed by DCID. It is envisioned that this lease would allow DCID to utilize the Deer Creek water during periods of fish non-migration. It is also envisioned that during periods of critical need, the agreement would allow DCID to bypass water in excess of the long-term lease amount, so as to provide an increased pulse of transportation flow. It may be necessary for the long-term lease to be implemented in a phased approached so as to provide DCID the necessary time for construction of surface water distribution improvements and supplemental water supply development.

Overall, the WAC served as a good forum to help manage the pilot program and disseminate information to members of the local community, as well as, local, county and state agencies.

FINDINGS AND RECOMMENDATIONS

Findings from the pilot program indicate that 85-days of groundwater extraction from the lower portion of the Tuscan aquifer had no groundwater level or water quality related impacts to existing agricultural and domestic wells that produce from the upper-middle portions of the aquifer. Findings also indicate that:

- Groundwater level drawdown impacts to the lower Tuscan aquifer ranged from approximately 16 feet at a distance of 375 feet from the pilot well, to 1.3 feet at a distance of 12,480 feet from the pilot well.
- The monitoring and web-based reporting methods were successful in disseminating data to the public in a timely manner.
- The WAC membership and the chain of partnerships that were utilized during development and implementation of the pilot program proved valuable for providing input and dispensing information to local, county and state groups.
- Although the production of the pilot well was less than anticipated, the additional water helped to increase the head in the delivery system, reduce water rotation times and improve water reliability.
- The fixed and annual operating costs associated with the pilot well program were relatively high and point out the need to explore additional methods of assuring an adequate water supply during surface water bypass periods. These methods should include evaluating the cost, benefit and impacts associated with improving the efficiency

of the water delivery and on-farm irrigation systems, and using existing wells to augment supply.
- With proper program management, comprehensive partnerships and the implementation of a good monitoring program, local agricultural, domestic and environmental water needs can be met without impacts to local and regional water users.

Recommendations at this time are to:
- Move forward with development of an expanded program that incorporates the conceptual components listed above, meets the approval of local, state and county agencies, and works toward a partnership with Stanford Vina Ranch Irrigation Company.
- Conduct additional meetings with the potential funding agencies, and a team representing the interest of local water users, local water purveyors, Tehama County AB 3030 plan, Deer Creek fisheries and Deer Creek watershed, to further define the scope and objectives of a water exchange program.
- Develop funding proposal(s) for infrastructure improvements to the water distribution system and the installation of additional deep-aquifer production wells and multi-completion monitoring wells.
- Develop language for a long-term, mutually beneficial, water lease agreement between the Deer Creek water purveyors and funding entities that includes a phased approach to full program implementation.
- Establish a funding source to continue operation of the pilot well in 2004.
- Revisit trigger level criteria guiding pilot well operations.
- Reevaluate quality control procedures for groundwater level datalogger operations in future programs to help eliminate potential data-gaps and equipment malfunction.